A MAINTENANCE MANPOWER STUDY OF THE COMPOSITE WING AT MOUNTAIN HOME AFB

THESIS

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THESIS

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and Acquisition Management
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In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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Preface

The purpose of this thesis is to determine if the composite wing structure warrants a different approach for determining maintenance manpower authorizations. The opinions of maintenance and manpower experts were collected and analyzed to determine what factors should be considered in the determination of maintenance manpower authorizations for the composite wing at Mountain Home AFB.

This research effort was made possible by the invaluable assistance of many people. Thanks to all the participants in the survey for taking the time to provide us with an abundance of interesting data. A special thanks to Major Johnson at Mountain Home AFB for helping us recognize the need for this research and coordinating efforts at Mountain Home AFB, Colonel Severs at HQ ACC for supporting the research effort and encouraging his experts to participate, and Mr. Gary Myers for providing a wealth of information. We would also like to thank our thesis advisors, Lieutenant Colonel Phillip E. Miller and Major Marsha J. Kwolek, for their tenacious, insightful direction.

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Abstract

In response to changes in threats, the Air Force has reorganized several flying units into composite wings. They are intended to provide a flexible, rapid deployment force. This study focused on the impact of the composite wing organizational structure on the determination of maintenance manpower authorizations at Mountain Home AFB, the Air Force's first air intervention wing.

An opinion survey of maintenance and manpower experts was used to identify factors that are important to the determination of maintenance manpower authorization levels. Statistical analysis identified important factors and indicated differences in opinion between maintenance and manpower specialists. Factors specific to the composite wing were also identified.

The researchers conclude that at a minimum, three factors must be accounted for in the maintenance manpower authorization process for the composite wing at Mountain Home AFB: *primary aircraft assigned (PAA)*, *utilization (UTE) rate*, and *deployment concepts*. The researchers also recommend efforts to minimize the difference in opinions between maintenance and manpower experts by increasing understanding of each others' perspectives through education and training.

A MAINTENANCE MANPOWER STUDY OF THE
COMPOSITE WING AT MOUNTAIN HOME AFB

I. Introduction

General Issue

Air Force composite wings have been formed to provide rapid response to the changing external threats since the end of the Cold War. There is a need for increased flexibility to facilitate rapid response to a wider spectrum of conflicts. General Merrill A. McPeak, Air Force Chief of Staff, has been a driving force behind the concept of the composite wing. He believes "such wings would be able to deploy the whole range of air capabilities to any part of the world. This fits well with the integrating vision now offered by the concept of 'Global Power--Global Reach'" (19:12).

One such wing that has been formed is the air intervention composite wing at Mountain Home Air Force Base (AFB), Idaho. The wing is composed of F-15Es, F-15Cs, KC-135Rs, F-16s, and B-1s. The wing initially included B-52Gs. The wing's mix of aircraft will provide the capability for air superiority, long-range interdiction, multi-role fighters, and air refueling. According to General Loh, Commander of Air Combat Command, the unique

requirements of the composite wing will result in increases in manpower requirements in aircraft maintenance career fields (2:15).

One critical resource for mission accomplishment is manpower because "as organizations become more complex manpower planning becomes more critical" (27:vii-viii). With today's shrinking military budget, it is even more critical for manpower authorization levels to be determined correctly. Adequate manpower is essential to mission accomplishment and overmanning means less money allocated to other resources because

> resources for additional military manpower requirements may be allocated only when an offsetting resource can be identified and transferred to satisfy the new requirement. (10:4)

The organizational structure and mission of the composite wing may present specific factors which must be accounted for in the determination of maintenance manpower requirements. However, these factors have yet to be explicitly identified.

Research Objective

The purpose of this research is to identify the factors that are important in the determination of the maintenance manpower authorization levels at Mountain Home AFB by reaching a consensus among maintenance and manpower experts.

Investigative Questions

The following investigative questions must be answered to appropriately meet the research objective:

1) How were maintenance manpower authorization levels estimated for the composite wing at Mountain Home AFB? What manpower equations, if any, were used?

2) What factors are important in the determination of maintenance manpower authorization levels? Why are these factors important?

3) Are there any factors specific to the organizational structure and mission of the composite wing at Mountain Home AFB that are important in the determination of maintenance manpower authorization levels? Why are these factors important?

4) Are there significant differences in the opinions of maintenance and manpower experts concerning the factors important in the determination of maintenance manpower authorization levels?

5) What factors should be considered in the development of maintenance manpower authorization levels at Mountain Home AFB if changes were to be made?

Scope

The scope of the research is focused on maintenance manpower authorization levels at the composite wing at Mountain Home AFB. The narrow scope of the research efforts will limit the generalizations and conclusions drawn from

the results of the analysis. Different methods are used in determining manpower authorization levels for maintenance personnel and levels for other support specialties, so our conclusions will be limited strictly to maintenance manpower authorization levels. In addition, since our data collection is limited to Mountain Home AFB, generalizations of the results for other wings, composite or not, will be minimal.

Thesis Overview

Chapter II encompasses a literature review, including background information about the concept of the composite wing, its advantages and disadvantages, and the validation of the concept during the Persian Gulf War. Logistics implications of the composite wing concept and the operations of the air intervention wing at Mountain Home AFB are discussed. In addition, the chapter addresses manpower issues and the Air Force regulations which govern the determination of manpower authorization levels.

Chapter III explains the methodology used. The Delphi Technique and its appropriateness for this research study are explained. Questionnaire construction and data analysis are detailed.

Chapter IV explains the analysis and findings, and Chapter V summarizes our conclusions and recommendations, including recommendations for further research.

II. Literature Review

Overview

This literature review is separated into two distinct sections. The first provides background information about the concept of the composite wing, as discussed in current military periodicals and research studies. The second half addresses manpower issues, including Air Force regulations and guidance on the determination of manpower authorization levels. Previous theses that are applicable to manpower studies are also reviewed, revealing a void of studies directly relating manpower issues with the organizational structure of the composite wing.

The Composite Wing

Background. During the last few years, changing external threats and smaller defense budgets have brought about major restructuring at all levels of the United States Air Force (USAF) (17:1). These changing external threats, which have become evident since the end of the Cold War, are forcing the Air Force to become more mobile and flexible for rapid response to a wider spectrum of conflicts (16:3). Composite wings have been formed as a response to these changes. General Merrill A. McPeak, USAF Chief of Staff, has been a driving force behind the composite wing since the publication of his article "For the Composite Wing" in the Fall 1990 issue of *Airpower Journal*. A review of the

literature available about the composite wing provides adequate background information about the concept. The definition of the composite wing and some of the obvious advantages and disadvantages of its organizational structure are addressed. In addition, the literature indicated that a provisional composite wing, established during the Persian Gulf War, validated the concept of the composite wing by reinforcing the increased combat effectiveness (22) and added flexibility of that unit (11).

Definition. Brigadier General Billy M. Knowles, Sr. defines the word composite as "the integrated use of multiple disciplines of one service" (8:278). The Air Force composite wing consists of a variety of types of aircraft with different missions on one base and under one wing commander. These wings diverge from the traditional organizational structure of the monolithic wing, where large numbers of aircraft of the same type are based together to take advantage of economies of scale. The composite wing commander has all the resources available to form composite force packages (19:8-9).

A distinction should be made between composite wings and multimission wings. In a multimission wing, a variety of aircraft belonging to separate wings already collocated are merged into one wing, with the consolidation resulting in reductions of overhead costs (17:17). Composite wings, on the other hand, are built from the ground up and are

"dedicated to force projection in the early stages of conflict" (4:20).

The Air Force has already built two composite wings for the purpose of rapid response, each with a different mission. The first is the air intervention wing at Mountain Home AFB, which consists of F-15Es, F-15Cs, B-52Gs, F-16s, and KC-135Rs. This wing is "organized to reach out over long distances and take immediate strike action" (23:11). The second is the rapid insertion wing at Pope AFB, which consists of A-10s, F-16s, and C-130s. This wing will support the deployment of the Army's 82nd Airborne Division from Fort Bragg and currently trains with the 82nd in peacetime (4:20).

Advantages. According to General McPeak, one of the composite wing's greatest advantages is the fact that it can "reform the command and control system by cutting back sharply on the need for guidance from above" (19:8). He believes one major problem with the system now is the length of time in the air tasking order (ATO) planning cycle. The ATO includes all the information pertinent for units supporting a theater campaign. This includes information about targets, timing, ordinance, and fuzing. The ATO planning cycle usually takes 72 hours from the beginning of the planning cycle through the time of execution of the plan. The length of the ATO planning cycle makes the process unresponsive to the changes in the dynamic

environment of combat. Another major problem is the system heavily relies on sophisticated command and control systems (19:6).

A composite wing is organized to reduce the magnitude of those two problems considerably. A simplified ATO, which would only "provide the target, objective, and time" (22:18) would give the wing commander more autonomy in the employment of his forces. This simplified ATO will shorten the length of the planning cycle and reduce the dependence on an extensive command and control system. In addition, "the composite wing's capacity for rapid tactical coordination significantly reduces reaction time" (22:18), making the process more responsive to rapid changes in the combat environment. The simplified ATO planning process is more in tune with the tenet of centralized control and decentralized execution of Air Force doctrine (7:8).

Air Force doctrine also states that, as much as possible, units should be "organized for wartime effectiveness rather than peacetime efficiency," and "organizational structures should be designed...to make aerospace forces responsive (and) flexible" (7:17). The composite wing's assets are organized in peacetime as they would be in war. The wing routinely trains in a peacetime environment using composite force packages. They train like they would fight, giving the aircrews opportunity to become extremely knowledgeable about their responsibilities as part of the composite force package. The learning curve is

reduced, and the wing is ready to go into combat immediately and effectively. This advantage, stated General McPeak, enables the composite wing to "exploit the inherent flexibility of airpower" (19:11).

Disadvantages. Perhaps the major disadvantage of the organizational structure of the composite wing is its increased cost. General McPeak recognizes that the composite wings will be more expensive, and that the "cost differential is driven by the degree of intermediate level maintenance" (19:9). Because the level of intermediate level is the cost driver, he believes the composite wing should operate under a two-level maintenance concept, where repairs of line replaceable units are performed at the depot level. Two-level maintenance will improve the deployability of the wing and reduce the costs associated with increased manpower and equipment requirements (19:9).

The trade-off with a two-level maintenance concept is the increased levels of spare parts required at the base level. Although the increased reliability and maintainability of systems helps neutralize the upward trend in spares requirements, the net increase is still an important consideration. This net increase in spares requirements emphasizes the fact that "the timely delivery of parts is a challenge that must be addressed" (11:15) if the composite wing will be able to deploy successfully for an extended period of time. In essence, for the concept of

the composite wing to be successful, "we must have either timely resupply or high component reliability" (17:16).

Validation During the Gulf War. During the Persian Gulf War, the 7440th Composite Wing (Provisional) based at Incirlik, Turkey, consisted of F-111s, F-16s, F-15s, KC-135s, F-4Gs, EF-111s, E-3Bs, and EC-130s. It was organized in the same manner as the stateside composite wings, with all the forces placed under one wing commander. The 7440th flew 4600 day and night combat sorties without a loss, and its success "highlighted the advantages of the composite wing" (23:13).

The Wing Commander of the 7440th, Brigadier General Lee A. Downer, stated that his planners were "given a target list but had the latitude to develop a campaign that would best attack those targets" (11:9). The centralized control and decentralized execution was a clear advantage to the unit; the unit had flexibility in the employment of its forces to complete the mission. The 7440th reduced the ATO cycle from 72 to 28 hours, increasing flexibility and responsiveness to changes in the combat environment (11:9). The success of the 7440th in the Persian Gulf War helped validate the concept of the composite wing and its increased effectiveness in combat since "many of the real lessons learned (lie)...in consideration of how effectively (end results) were achieved under operative conditions" (22:25).

Composite Wing Operations. In his research study, Lieutenant Colonel William Egge states that three characteristics of the composite wing are important: speed, range, and flexibility. The concept requires the composite wing to have the ability to respond to regional threats anywhere in the world rapidly, and this capability requires a high degree of readiness. Range assures that the composite wing will be able to strike anywhere, supporting the concept of global reach, either with long range bombers or using air refueling capabilities. The third characteristic, flexibility, requires the composite wing to be able to respond to a "variety of threats across the spectrum of conflict" (12:27).

Mountain Home Air Force Base. Egge states that "composite wings will be assigned one of two general principal roles with overlapping capabilities: the role of aerospace control and the role of application" (12:29). The 366th Wing at Mountain Home AFB will be able to "rapidly deploy a highly trained composite force, and successfully plan and execute autonomous air operations in any theater, region, or contingency area in support of US/allied national and/or military objectives" (12:33). The wing is "the only wing in the Air Force that could be directly tasked by the national command authority, a provision meant to enhance the wing's rapid deployability" (3:12). The 366th Wing is the Air Force's first air intervention wing, fulfilling the role

of aerospace control, which includes such missions as offensive counterair, defensive counterair, suppression of enemy air defenses, air interdiction, and strategic aerospace offense (12:34). Initially, the posture of the wing is expected to be a defensive one. The second priority will be force application (12:29).

The concept of operations of the 366th Wing at Mountain Home AFB is unique. The wing may be required to

> deploy and operate up to seven days without resupply, and may be tasked to operate from bare-base locations. The draft concept of operations allows for the potential use of multiple bases during the deployment, but this is not considered an optimum employment of composite force capabilities. (12:34)

The wing may be required to "fight unsustained for seven days, and for another 23 days with resupply" (3:12). In order to facilitate rapid deployment, the wing was initially developing packages tailored to respond to different levels of conflict (3:14). Planning what these packages will be in advance allows the wing to train for each and "lets logisticians figure out which support assets would have to be deployed" (3:14). This planning ensures that the tailored unit type codes (UTC) employ only the "parts of the wing that are needed for the mission at hand" (12:31).

Manpower

One of the major activities necessary for creating an Air Force organization is manpower planning. Organizational changes in the Air Force, including the implementation of

the composite wing concept, have put new demands on the current manning process and "as organizations become more complex, manpower planning becomes more critical" (28:vii-viii). This literature review focuses on the guidance used for Air Force manpower determination and previous studies related to manpower and manning issues. The discussion of the regulations explains how Air Force unit's maintenance manpower requirements are supposed to be determined. The explanation of previous studies shows that research evaluating which factors of the composite wing structure should be considered during maintenance manpower authorization decisions will be an addition to existing literature. The literature review also revealed a lack of any research efforts which used the Delphi Technique to evaluate the manpower authorization process. Definitions are included in Appendix A.

Determination of Authorizations. Air Force Regulation (AFR) 26-1 provides manpower management policies and procedures for determining, programming, and using Air Force manpower resources. The Air Force manpower requirements determination process uses a bottom-up approach, whereby information about workloads is collected at the organizational level then forwarded to the major command, where determinants are applied which objectively state manpower requirements as a function of workload. These determinants exist in two forms, standards and guides.

Standards are documentation of a statistically determined, quantitatively expressed manpower requirement, defined by grade and specialty, to accomplish varying levels of workload. The standards provide a tool to determine and measure each task in a workcenter through accepted industrial engineering techniques and should provide an accurate objective measure of manpower requirements for a given volume of workload. Using the standards, the impact of program changes, changes in level of service, or changes in level of effort can be objectively translated into a manpower requirement. Guides, the second form of determinant, are document expressions of manpower allowed for workload and are generally used where workcenter size or swiftly changing procedures make standards development costs prohibitive, and where temporary or unusual situations occur. These guides use estimating methods such as contract estimates, staffing estimates, crew ratios, maintenance man-hour per flying hour factors, and simulation (9:5).

Once the decision is made about which determinant to use, manpower requirements are determined from the standards or guides with the intent of providing adequate manning to "ensure effective and economical accomplishment of approved missions and functions" (9:5). Each standard and guide is systematically reviewed and reapplied annually.

Aircraft maintenance manpower requirements can be determined by conventional manpower determinants (standards and guides) or the Logistics Composite Model (LCOM) manpower

determinants. LCOM, a simulation model developed jointly by Air Force Logistics Command and the Rand Corporation in 1968, includes the factors of aircraft operations, maintenance, and support concepts. If these factors are not available, AFR 26-1 allows for determination using man-hour per flying hour (MMH/FH) factors. These computations are intended to be limited to systems whose small numbers or pending departure from the inventory make the more thorough and accurate manpower determination uneconomical (9:29).

Maintenance Manpower Authorizations for Mountain Home. A telephone interview with Mr. Gary Myers, of Headquarters ACC, provided information about how the maintenance manpower authorizations were determined for Mountain Home AFB prior to its activation as a composite wing. Because no specific procedure existed for determining authorizations at a composite wing, a combination of methods was used. LCOM was run to determine the authorization levels for the F-16 squadron. For all other aircraft types at Mountain Home AFB, unit manning documents (UMDs) from other individual units were used to determine maintenance manpower authorizations. For the F-15Cs, F-15Es, KC-135Rs, EF-111s and B-52Gs, the UMDs from standard wings were adjusted for the number of airframes assigned to Mountain Home AFB. Maintenance manpower authorizations for Mountain Home AFB were determined based on this adjustment. Using LCOM results for the F-16 squadron, and estimations based on

other units' UMDs for the remainder of Mountain Home's flying squadrons, maintenance manpower authorization levels were prepared in time for the activation of the composite wing at Mountain Home AFB (20).

Previous Studies. Manpower authorization has been the topic of many AFIT theses. These document different approaches to evaluating manpower requirements and present various variables which have been considered important for manpower calculations.

One method of evaluating manpower calculation adequacy which has been used repeatedly in research efforts is computer modeling. Rumple and Green attempted to develop a model of a maintenance complex required to support a weapons system. They used a series of computer simulations with a goal of 95% sortie effectiveness. They manipulated inputs and ran the simulation repeatedly until the 95% rate was achieved. At this point they looked at the input factors and decided which manning levels had produced the desired output. The only variable considered was flying hours per month (26).

Reusche and Wasem also used the simulation approach to determine adequate manning for aerial ports. They attempted to develop a quantitative model to represent a functional relationship between variables affecting aerial port service. Their main goal was to model the aerial port and

analyze what the optimum manning level would be. The variables considered were processing time and manpower (24).

Barney, Carpenter, and Samuels attempted to identify significant variables which can be used to determine optimum number of Quality Assurance specialists to be collocated in contractor facilities to help the Air Force administer contracts for large weapons systems. After determining the variables they wished to evaluate, they used a survey to collect data about contracts and quality assurance personnel employed at contractor facilities. They then ran a regression analysis on the results and found that spares contracts, total contract dollar value, and number of material review actions accomplished were the most critical variables (1).

Klovstad and Rhodes used computer simulation and the Logistics Composite Model (LCOM) to evaluate a base communication maintenance system. They determined modifications necessary to make the LCOM useful for predicting communication maintenance personnel needs (15).

In his thesis, Seaman built a model to identify the material management manpower requirements for Air Force consumable items. He developed a mathematical model capable of predicting manpower requirements and analyzed data for a relationship between workload factors. He used twelve workload variables relevant to material management manpower, some of which were aircraft flying hours, total aircraft in the inventory, replacement items and stock items (27).

Neuhaus evaluated manning and manpower measurement in civil engineering. In his study he developed a method to measure capability by comparing required manpower, authorized manpower, and assigned manning capability while considering the qualitative and quantitative manpower factors of experience, technical ability, and quantity. He emphasized the difference between authorized and required manpower levels and showed that a method of determining capability which does not account for this difference can produce false capability measurements (21).

Chapter Summary

The literature review indicated that composite wings have been developed with a capability of rapid projection of force in response to shrinking budgets and changing external threats. The Air Force has had to find innovative ways to rapidly respond to a greater variety of conflicts. The organizational structure of the composite wing has clear advantages and disadvantages, but the wing's success in combat, as evidenced during the Persian Gulf War in the 7440th Composite Wing (Provisional), demonstrated the composite wing's increased effectiveness and flexibility in combat. The composite wing "fits well with the integrated vision offered by the concept of 'Global Power--Global Reach'" (19:12).

This literature review also summarized current Air Force guidance for the determination of maintenance manpower

authorizations. The research efforts cited show that there is continuing concern over the adequacy of the existing process. A common trend in the literature is the acknowledgment that each situation for which manpower is to be determined has unique variables. The literature review revealed that there is no research in this area which utilizes the Delphi Technique to evaluate the factors considered in the maintenance manpower authorizations development. This technique, applied to the composite wing at Mountain Home AFB, will add to existing literature as a new approach for evaluating the manpower allocation process.

III. Methodology

Overview

The literature review showed that there is no existing research which specifically addresses the issue of factors important for determination of maintenance manpower authorizations for the composite wing at Mountain Home AFB. Once this need was determined and the appropriate investigative questions were established, the next step was to develop a methodology appropriate for collecting and analyzing the necessary data. This chapter explains how and why the Delphi technique was employed to collect data. It includes the rationale for selecting the experts, the process of constructing the three questionnaires, the conducting of pretesting, and issues of reliability. This chapter also includes a detailed plan for data analysis.

Background Information

The literature review provided the background information concerning current Air Force manpower regulations and previous research in the area of manpower necessary for the development of the first questionnaire. Manpower experts at Air Combat Command Headquarters Manpower and Organization (ACC/XPM) provided the information needed to answer the first investigative question, concerning how the maintenance manpower authorizations were estimated for the composite wing at Mountain Home AFB. The results of this telephone interview with Mr. Gary Myers, from the

Maintenance Section of the Requirements Branch at ACC Headquarters (ACC/XPMRM), were incorporated into the literature review (20). The information gathered provided insight into how the maintenance manpower authorization levels were estimated for the composite wing at Mountain Home AFB.

The Delphi Technique

For this research effort, the Delphi Technique was selected as the most appropriate methodology because it gathers information from those most familiar with the problem being studied. The most accurate method to identify factors that are important for the determination of maintenance manpower authorization levels at Mountain Home AFB was to solicit the opinions of experts familiar with both manpower and maintenance issues related to the composite wing.

The Delphi Technique was developed by the RAND corporation in the 1950's to "eliminate the negative effects related to the use of interacting groups for decision making" (25:89). These negative effects include the tendency of individuals to agree with others of higher status or dominant personalities and the pressures of the group for conformity. Research indicates interacting groups tend to reach compromise decisions instead of consensus decisions (25:89).

The Delphi Technique eliminates interaction by collecting written responses. It begins with the definition of the problem and the determination of expertise required. The sample of experts is selected, and these individuals respond to written questionnaires. Data are then analyzed, and the results are incorporated into subsequent questionnaires. The process continues until a consensus, as defined by the researchers, is reached (25:90).

The Delphi Technique is also "particularly useful in soliciting information from participants who cannot physically come together," (25:90) which was the case for the experts selected to participate in this study. Because the scope of the research focused on maintenance manpower authorization levels at Mountain Home AFB, experts were selected from Mountain Home AFB and Langley AFB, where the determination of authorization levels was made for the composite wing.

The experts in this study were approximately equally divided between maintenance and manpower. A simple majority was considered insufficient for a consensus between the two communities because it did not imply a consensus across functional lines. The definition of a consensus of the experts is somewhat arbitrary, but previous Delphi studies define consensus as achieving agreement among two-thirds of the population of experts (6:147). Therefore, 66.7% was selected as the consensus level for this research study.

Selection of Participants

The population of experts chosen to participate in the Delphi study was composed of maintenance and manpower experts at both Mountain Home AFB and Air Combat Command (ACC) Headquarters at Langley AFB. Because this study focused on the determination of maintenance manpower levels for the composite wing at Mountain Home AFB, maintenance and manpower experts at the wing level were included. Manpower personnel at ACC Headquarters actually estimated the maintenance manpower authorization levels, and were therefore also included in the population of experts. The selection of experts was based on their assigned position in the unit and the assumption that the individuals had professional credentials in their respective fields which warranted their assignment to key positions.

All the experts available at Mountain Home AFB were included in the population: the commanders of all squadrons with maintenance personnel authorized, the senior maintenance officer and senior enlisted maintainer in each squadron, senior personnel in the manpower office, the operations group commander and deputies, the logistics group commander and deputies, the vice wing commander, and the wing commander. In addition, selected personnel at ACC/XPM were part of the population of experts. These individuals were identified by Colonel James S. Severs, ACC/XPM, and section chiefs in ACC/XPME, the Management Engineering

Office, and ACC/XPMRM, the Maintenance Section of the Requirements Branch.

In order to ensure that a consensus was not reached through a population of experts which was unbalanced toward the maintenance or manpower community, an approximately equal number of experts in maintenance and manpower was selected. The sample population included 21 manpower experts from Air Combat Command Headquarters, 23 maintenance experts from Mountain Home AFB, and 2 manpower experts from Mountain Home AFB. Appendix B includes a blind list of the 46 participants.

Data Collection

Once the participants were selected for the Delphi study, it was necessary to construct questionnaires to gather data. An open-ended questionnaire was used to solicit information needed to construct the subsequent closed-ended questionnaires.

The First Questionnaire. The purpose of the first questionnaire was to collect information needed to construct the survey for the subsequent rounds. It contained open-ended questions about what factors are relevant to the determination of maintenance manpower authorization levels and why these factors are important. The open-ended format was used to solicit as much information as possible, without limiting or leading the participants' responses. Appendix C includes the first questionnaire. Identification numbers

were assigned to the participants to ensure that only the respondents of the first questionnaire received subsequent rounds of the questionnaire.

Questions were constructed to collect both target data about factors used in determining maintenance manpower authorization levels and classification data about the respondents. Classification data were collected to determine if significant differences existed in the responses of sub-populations of the sample.

The first three questions gathered classification data about the respondent's Air Force Specialty Code (AFSC), total years of job experience, and duty title. The fourth question addressed investigative question number two. The target data were factors important to determining maintenance manpower authorization levels. The questionnaire also asked the respondent to list the factors in order of importance and justify why they considered them important. The fifth question addressed investigative question number three. It addressed any factors specific to the composite wing at Mountain Home AFB. The respondents were again asked to list their responses in rank order and explain the rationale for their rankings. The final question in the first questionnaire solicited any extra information important to the development of subsequent surveys. It was an open-ended question which allowed the experts to add any information which they thought was critical and was overlooked in the questionnaire.

The Second Questionnaire. The second questionnaire was only sent to the respondents of the first questionnaire and attempted to reach a consensus among the maintenance and manpower experts. Appendix D includes the second questionnaire.

This questionnaire incorporated the answers to the open-ended questions in the first questionnaire, where factors important to the determination of maintenance manpower authorization levels were determined. These factors included those applicable to all wings and those specific to the composite wing at Mountain Home AFB. Each question was directed to collect information about one factor. All questions were closed-ended in structure and asked respondents to rate the factors using both a Likert scale and a method of rank order.

Likert Scale. The Likert scale allows respondents to "express either a favorable or unfavorable attitude toward the object of interest" (13:219). This method was chosen because it indicates the degree of a respondent's approval or disapproval. A five-point Likert scale was chosen because it provided a sufficient amount of information regarding the degree of approval or disapproval. A sixth point on the Likert scale gave the respondent the option to not answer a question about which they knew nothing.

Method of Rank Order. The respondents were asked to select the ten most important factors and rank them from most important to least important. They were also asked to select the five least important factors and rank order them. This provided information about how important the respondents perceived the factors to be with respect to each other. In addition, it provided a measure of reliability by allowing an assessment of internal consistency in an individual's responses. For the factors selected in the top ten or bottom five, the respondent's Likert scale responses were reexamined to identify inconsistencies. For example, if a factor in the top ten was given a Likert rating of "1", very low in importance, then the responses were inconsistent. Only obvious inconsistencies were identified and discarded.

The Third Questionnaire. The third questionnaire was identical to the second questionnaire, except that it included results from the second questionnaire. The Delphi Technique is an "iterative feedback process by which individual experts share their views" with other experts (6:137). This feedback was provided by including results of the second questionnaire in order to expose the respondents to the opinions of other experts. The results were included in an attempt to reach a higher level of consensus. This survey was only sent to respondents of the second questionnaire and is included in Appendix E.

Pretests. Once each questionnaire was constructed, pretests were conducted to determine clarity and to optimize internal validity, which "refers to the extent to which a test measures what we actually wish to measure" (13:179). Pretests were conducted with AFIT graduate students who have experience in maintenance or manpower. The pretest subjects were asked to identify anything unclear, such as wording or format. Inputs from the pretests were incorporated into the questionnaires before they were sent to the experts.

Data Analysis

Data from the first questionnaire were collected for incorporation into the second questionnaire, and analysis of this data consisted of interpreting respondents' answers to the open-ended questions. Answers were evaluated for appropriateness and similarity. Answers which did not directly answer the questions, and thus did not provide target data about factors important in the determination of maintenance manpower authorizations, were discarded. Answers which had essentially the same meaning were combined into one factor. The factors identified through this process were incorporated into the second questionnaire. In addition, valuable comments about maintenance manpower issues for the composite wing were consolidated to provide a broader representation of opinions.

Data collected in the second and third questionnaires were analyzed using Microsoft Excel and STATISTIX 4.0. The

main objective of this research was to determine whether consensus was reached about important factors in the determination of maintenance manpower authorizations. Histograms were produced for each factor to illustrate the frequency of responses for each point on the Likert scale. In order to determine the level of agreement for each factor, the frequency of the most common response on the Likert scale was divided by the total number of responses for that factor. The level of agreement was compared to the definition of consensus, stated as 66.7% for this research study. If the level of agreement for a factor was greater than 66.7%, then consensus was reached.

For factors where consensus was not reached for an individual point on the Likert scale, responses were grouped. The Likert scale responses of "1" and "2" were grouped because they both indicated that the experts did not consider the factor important in the determination of maintenance manpower authorization levels. Likewise, responses of "4" and "5" were grouped because they both indicated the factors were considered important. This grouping provided information about whether the experts generally agreed or disagreed about the importance of a factor. Additional histograms were produced after the responses were grouped, and the results were evaluated to determine whether consensus was reached.

The responses of the maintenance and manpower experts were analyzed to see if statistically significant

differences existed. First, the data were analyzed to determine whether there was an overall difference in the means of the responses. The means of the responses from the maintenance experts were compared to the means of the responses from the manpower experts. The data were tested for normality. If normality was indicated by the Wilk-Shapiro test, a paired difference test was used to compare the means. If normality was not indicated, then a non-parametric test, the Wilcoxon Signed Rank test, was used. The following hypotheses were tested:

Ho: The overall means of the two populations are equal

Ha: The overall means of the two populations are not equal

After determining whether there was an overall difference between the responses of the maintenance and manpower experts, tests were performed to determine if there was a statistically significant difference for each of the factors. The Wilk-Shapiro test was used to test for normality. If normality was indicated and variances were approximately equal, then a t-test for independent samples was used to compare the means. Otherwise, the non-parametric Wilcoxon Rank Sum test was used. The following hypotheses were tested:

Ho: The means of the two populations are equal for a given factor

Ha: The means of the two populations are not equal for a given factor

The last step in data analysis was interpreting the rank order responses. This section was included for the specific purpose of providing internal consistency, and the most important information to be extracted from the data was a list of the factors with the highest response rates. A simple count of the number of times a factor was mentioned in the top ten provided two lists of the top ten factors, one for maintenance experts and one for manpower experts. The same method was used to compile two lists of the bottom five factors. These lists were qualitatively compared to the results of the Likert scale analysis to determine if there was consistency in results.

Chapter Summary

This chapter detailed the methodology used to collect and analyze the data necessary to answer the investigative questions. It provided an explanation of the Delphi Technique and justification of its appropriateness for this research. The population of experts was described and issues of survey development and question construction were addressed. This chapter provided the framework for the data analysis which will be presented, along with findings, in Chapter IV.

IV. Analysis and Findings

Introduction

Chapter III presented the methodology for data collection and analysis. This chapter presents the results of the analysis of data collected from the first and second questionnaires. The results include qualitative descriptions of trends found in responses to the open-ended questions and quantitative analysis of the responses to the second questionnaire. Factors for which consensus was reached are identified, and a list of most important factors and a list of least important factors for each population of experts is included. Statistically significant differences in the opinions of the experts are discussed. In addition, this chapter contains an explanation of a change in methodology which occurred after responses from the second questionnaire were analyzed.

The First Questionnaire

The objective of the first questionnaire, which consisted of open-ended questions, was to compile a list of factors considered important to the determination of maintenance manpower authorization levels for the composite wing at Mountain Home AFB. Maintenance and manpower experts were asked to list factors they consider important to determination of maintenance manpower authorizations for all units. In addition, they were asked to identify any factors important to determination of maintenance manpower

authorizations for the composite wing at Mountain Home AFB. The first questionnaire is included in Appendix C.

Response Rates. The first questionnaire was sent by government mail to 23 manpower experts and 23 maintenance experts. Eighteen questionnaires were returned by the manpower experts, for a response rate of 78.26%, and fifteen were returned by maintenance experts, for a response rate of 65.22%. The overall response rate was 71.74%.

Identification of Factors. The first step in the analysis of data collected by the first questionnaire was determining which responses were appropriate for incorporation into the second questionnaire. In response to the request for a list of factors important in the determination of maintenance manpower authorization levels, several respondents failed to identify specific factors. Some respondents wrote narratives describing the process by which authorization levels are determined. For example, one respondent stated that "the Air Force is here to protect our country and to fight and win a war." This answer failed to identify a factor and was therefore considered inappropriate. All other answers which did not identify factors were also considered inappropriate and were not incorporated in the compiled list of factors.

After appropriate responses were compiled, these responses were evaluated for similarity. Responses which had essentially the same meaning were grouped into one

factor. For example, "aircraft assigned" and "primary aircraft assigned" were grouped into one factor: *primary aircraft assigned (PAA)*, and "types of aircraft supported" and "mission design series (MDS)" were grouped into another factor: *type of MDS*. Table 4.1 shows the fifty factors identified. Factors identified which were specific to the composite wing are asterisked.

TABLE 4.1 Factors Identified

Primary Aircraft Assigned (PAA)	Maintenance Concept
Backup Aircraft Inventory (BAI)	Operating Environ/Base Location
Type of Mission Design Series (MDS)	Scheduled Maintenance Required
Age of Fleet	Maintenance Policies
Additional Aircraft Systems	Support Equipment Available
* Multiple MDSs	Manpower Standards
* MDS Assigned Out of Traditional MAJCOM	Results of Logistics Composite Model
Funded Flying Hours	Maintenance Facilities Layout
Utilization (UTE) Rate	Aircrew Ratio
Average Sortie Duration (ASD)	Types of Munitions
Unit/Wing Mission	Minimum Crew Size
* Wing Organizational Concept	Minimum Required Specialists
* Mobility Taskings	Parts Levels
* Deployment Concepts	* Shared Resources Between MDSs
* Wartime Team Requirements	Officer/Enlisted Ratio
Wartime Munitions Load/Expenditure Rates	AFSC/Grade/Skill Level Requirements
* Geographically Separated Unit (GSU)	* Staff Positions Required by Regulation
Temporary Duty Assignments (TDYs)	Aircraft Turn Time
R&M Improvements	Number of TCTOs
Mean Time Between Failures (MTBF)	Munitions Rates of Buildup
Maintenance Manhours Per Sortie	Accuracy of CAMS Data
Aircraft Maintainability	Manhour Availability Factors
Mean Sorties Between Maint Action	Maintenance Fix Rates
* Mobility Processing/Aircraft Generating Simultaneously	* Effects of Multiple MDSs on Backshop Training
* Wartime Sustainability Up to and Beyond 30 Days	Availability of Fuel Tank Buildup Augmentees

Trends Identified. The experts' responses contained valuable information beyond identifying the fifty factors. The responses contributed insight into experts' opinions about the determination of maintenance manpower authorizations for the composite wing at Mountain Home AFB. To interpret this data, the responses were grouped by trends of opinions. Eight trends were identified and are discussed in the following sections.

Logistics Composite Model (LCOM). One trend noticed in responses from manpower experts, which was not present in the responses from maintenance experts, was the identification of LCOM as an important tool for the determination of manpower authorizations. Several manpower experts cited LCOM as a significant factor and felt strongly enough about LCOM to give elaborate responses emphasizing its importance. One respondent explained that "LCOM is a simulation approach which deals with random variations in workload by estimating the sortie 'risk' of different manpower levels." He asserted that "simulation is by far the most accurate and cost effective way to determine aircraft maintenance manpower--everything else is just a guess." LCOM was not identified as important by any of the maintenance experts when they responded to the open-ended questions. This difference in trends between manpower and maintenance experts could indicate that either maintenance

experts felt that LCOM was unimportant or that they were unfamiliar with LCOM.

Core Automated Maintenance System (CAMS) Data. A second trend noticed in responses included comments about the accuracy of CAMS data. Manpower responses emphasized the connection between accurate CAMS data and LCOM results. One manpower expert explained that CAMS training must emphasize that "job counts (which record the number of times a system fails) must be #1 priority..." because LCOM uses the failure rates of the aircraft systems as an input. He also stated that CAMS data should accurately reflect the maintenance performed on each weapon system Air Force wide because "different LCOM studies for other bases are used to determine Mountain Home's manpower requirements." None of the maintenance experts identified the accuracy of CAMS data as an important factor in response to the open-ended questionnaire, which is unusual because CAMS is the primary data collection system for maintenance. If maintenance experts understand the connection between CAMS data and LCOM results, which ultimately drives manpower authorizations, it seems likely that the accuracy of CAMS data would be recognized as important by maintenance experts as well as manpower experts.

Training. Not all of the trends noticed during compilation of the data from the first questionnaire reflected differences in opinion between maintenance and

manpower experts. One area which both groups of experts identified as important, and elaborated on, was training.

Maintenance experts repeatedly expressed concern about the adequacy of training. One respondent wrote about the difficulty of maintaining sufficient numbers of qualified personnel. He stated that the units need high enough authorizations to "maintain availability of trainers and maintain qualifications on all airframes assigned" because small shifts in balance create immediate problems.

Some manpower experts also expressed concern about training. One respondent expressed concern about backshop manpower and training requirements: "the exact roles and responsibilities of each (backshop) need to be clearly delineated. For instance, will the B-1B Integrated Automated Test Equipment (IATE) shop operate independently, or will it be combined with another IATE shop to consolidate test equipment and realize manpower efficiencies?" Another manpower expert expressed concern about the experience level of maintenance personnel. "The mission of Mountain Home does not lend itself readily to the training of new Air Force members. Assignment should be limited to career airmen (no trainees fresh out of tech school)." There was similarity of opinion expressed by the two groups of experts concerning training issues.

<u>Cooperation</u>. The responses from maintenance experts and manpower experts were similar in addressing the

importance of cooperation between manpower specialists and their customer. One manpower expert's response conveyed an interest in increasing cooperation between the manpower specialists and their customers. He stated that it is important to keep "the customer actively involved in the process from start to finish" and ensure the data input matches the actual operating environment as closely as possible. Maintenance experts also expressed an interest in increasing cooperation between unit personnel and manpower personnel. One respondent stated that there is a need for "units to have an input to requirements."

Economies of Scale. Another trend in opinion which was similar for maintenance experts and manpower experts concerned the impact of the composite wing's structure on economies of scale. Several comments addressed the fact that the composite wing structure eliminates economies of scale. This concern was directly addressed by comments about geographically separated units. One manpower expert stated that "a geographically isolated unit will require a complete compliment of overhead, thus reducing any opportunity to realize any economies of scale." Maintenance experts were concerned about losing economies of scale also, particularly with regards to the backfilling of maintenance personnel during aircraft generations and mobility processing. One maintenance expert explained that "with the composite wing you lose the economy of scale a single MDS

wing has... no backfilling a KC-135 troop to the F-16s in a generation." The practice of using members of a secondary squadron to generate aircraft while the members of the primary squadron are processing for mobility has been used by the traditional wing. This practice is impossible in the composite wing because there is only one squadron of each type of aircraft. Both the manpower and maintenance experts recognize the loss of economies of scale, yet the manpower standards used to determine the maintenance manpower authorizations for the composite wing at Mountain Home AFB were applied ad hoc, using parts of separate MDS standards to compile an authorization level for the weapons systems in the wing. The determination of manpower using pieces of standards for each MDS did not account for the loss of economies of scale.

Deployment concepts. Many experts named *deployment concepts* as a factor important to the determination of maintenance manpower authorizations for the composite wing at Mountain Home AFB. One maintenance expert expressed concern about being able to support all deployment packages. He stated that "the mission calls for generation of three packages of composite wing aircraft. Limited maintenance manpower makes it difficult to generate the larger packages." The trend of opinion from the maintenance experts indicates that maintenance personnel at the unit level do not feel comfortable that they can meet the wartime

mission with current manning. A maintenance expert stated that "the most important issue is how to calculate personnel requirements for the wartime mission. It's very difficult at the unit level to feel comfortable with existing numbers." Another maintenance expert stated: "if you are expected to deploy to more than one location, or operate at home station and deployed, it has a major impact on manpower." Manpower experts also recognized the importance of deployment concept when determining maintenance manpower. One manpower expert stated that a consideration in determining manpower is whether they will "deploy as a wing or splinter."

Because the mission of the composite wing is to provide a rapid, flexible response force, it is critical that the wing is manned to successfully accomplish this mission. The unit must be confident that it has the necessary resources to perform its wartime mission. Maintenance experts must be confident that they are sufficiently manned to accomplish the mission. The trend shown in responses to the first questionnaire indicates that the maintenance experts are not currently confident in the adequacy of the maintenance manpower levels.

Skill Level Mix. Maintenance manpower authorization levels may not always result in a proper mix of skill levels. Both maintenance and manpower experts expressed concern over mismatched assignment of personnel to

authorized positions. One manpower expert discussed the limitations of the efforts of the manpower experts who determine authorizations. "The personnel function must be responsive. Manpower can determine the maintenance requirements with a great deal of accuracy only to have an improper mix of assignments placed in the wing." Several maintenance experts also pointed out that the personnel function can have a significant impact on the actual workforce. This concern about the improper use of authorizations by the personnel function is not a factor which can be used to help determine appropriate maintenance manpower authorizations, but it is clearly a factor which contributes to the proper manning level and skill mix in a maintenance force.

Staff Functions Required. A trend found in responses from maintenance experts which was not evident in responses from manpower experts was concern about staff functions being unfunded positions which must be filled by maintenance personnel. Concern about staff functions was expressed by many maintenance experts. One stated that "with a 600 man squadron there should be authorizations set for staff: safety, environmental, training, career advisor, resource manager, and mobility. These all come out of hide and affect shop manpower." Another stated that "the various out-of-hide positions within a squadron weakens the direct aircraft supporting/sortie generating AFSCs availability."

This respondent listed the same staff positions as the first respondent and added "facility manager, dorm manager, vehicle manager and training manager" He stated that "while not all these positions need to be authorized a funded manpower slot, some deserve serious consideration." None of the manpower respondents listed any concerns about the additional staffing requirements.

This issue has been recurring in the maintenance community. It is a continual concern that the staff positions which are crucial to the smooth operation of a squadron are not funded authorizations and thus must be manned by personnel filling maintenance authorizations. The composite wing exacerbates this situation by eliminating economies of scale. The multiple MDSs in a composite wing mean that the interchanging of maintainers is limited. Using maintainers to fill staff positions increases the difficulty in accomplishing the mission.

The Second Questionnaire

Once the qualitative analysis of the responses to the first questionnaire was completed, including the identification of eight trends in opinions, the fifty factors identified in Table 4.1 were incorporated into the second questionnaire. The second questionnaire is included in Appendix D.

The second questionnaire required respondents to rate each of the fifty factors using a Likert scale. In

addition, they were asked to rank the ten factors they felt were most important and the five factors they felt were least important. The second survey was pretested, and inputs from AFIT students resulted in clarification of the wording of some factors and a few format modifications. The fifty factors were grouped randomly into groups of ten to simplify the process of rating the factors. The randomness of the groups also encouraged the participants to evaluate each factor separately, instead of assigning a blanket rating to an entire category. The questionnaires did not indicate to the respondents which factors were specifically related to the composite wing, to prevent bias in responses.

Response Rates. The second questionnaire was only sent to the experts who responded to the first questionnaire. In order to expedite the process, the second questionnaire was transmitted by fax. This reduced the turn-around time by more than half, with responses returned within two weeks.

Eighteen questionnaires were sent to manpower experts and fourteen were returned, for a response rate of 77.78%. Fifteen questionnaires were sent to maintenance experts and twelve were returned, for a response rate of 80%. Thus, the overall response rate for the second questionnaire was 78.79%.

Analysis of Responses. Data collected from the second questionnaire were compiled and histograms were built, using Microsoft Excel, to show the frequency of responses for all

fifty factors. These histograms were used to help determine whether consensus was reached, and to present a graphical representation of the raw data. Histograms for all factors are included in Appendix E.

Consensus, defined by the researchers as 66.7%, was not reached for any factor for an individual point on the Likert scale. Some factors were close to consensus. The closest ones were *Utilization Rate*, with 57.69% of the respondents rating it as very important; *Unit/Wing Mission*, with 57.69% rating it as very important; and *Primary Aircraft Assigned (PAA)*, with 53.85% of the respondents rating it as very important.

Because consensus was not reached for any factors on individual points on the Likert scale, the next step was to group Likert scale responses and again look for consensus. Responses of "1" and "2" were grouped and responses of "4" and "5" were grouped. Responses of "1" or "2" indicate that the respondent rated the factor unimportant. Likewise, responses of "4" or "5" indicate that the respondent rated the factor important. After grouping, consensus was reached for eight factors, as detailed in Table 4.2. For seven of the factors, consensus was reached at a high/very high level of importance. Consensus was reached for only one factor at a low/very low level of importance.

TABLE 4.2 Factors in Maintenance Manpower Authorization Level, Consensus Reached

FACTOR	**Level of Consensus**	**Grouped Responses (Level of Importance)**
Unit/Wing Mission	92.31%	High, Very High
Utilization (UTE) Rate	92.31%	High, Very High
Deployment Concepts	88.46%	High, Very High
Primary Aircraft Assigned	76.92%	High, Very High
Wartime Sustainability up to and Beyond 30 days	76.92%	High, Very High
Officer/Enlisted Ratio	76.92%	Low, Very Low
Aircraft Maintainability	69.23%	High, Very High
Scheduled Maintenance Requirements	69.23%	High, Very High

Respondents were also asked to rank order the factors, and each respondent provided a rank order of the ten factors they considered the most important in the determination of maintenance manpower authorization levels and the five factors they considered the least important. The frequency of responses in these two lists appears in Table 4.3 and Table 4.4. Natural breaks appeared, and only those factors with frequencies above the break are included in the two tables.

TABLE 4.3 Factors Ranked as Most Important

Manpower Experts	Frequency	Maintenance Experts	Frequency
Utilization (UTE) Rate	10	Utilization (UTE) Rate	9
Deployment Concepts	9	Primary Aircraft Assigned (PAA)	6
Primary Aircraft Assigned (PAA)	8	Deployment Concepts	6
Accuracy of Core Automated Maintenance (CAMS) Data	8	Backup Aircraft Inventory (BAI)	6
Unit/Wing Mission	7	Aircraft Maintainability	5
Average Sortie Duration (ASD)	7	Mobility Taskings	5
Scheduled Maintenance Requirements	6	Scheduled Maintenance Requirements	5
Mean Time Between Failures (MTBF)	6	Multiple Mission Design Series (MDSs)	5
Minimum Crew Size	6	Parts Levels	4
Maintenance Concept	6	AFSC/Grade/Skill Level Requirements	4
Mean Sorties Between Maintenance Action	6		

TABLE 4.4 Factors Ranked as Least Important

Manpower Experts	Frequency	Maintenance Experts	Frequency
Officer/Enlisted Ratio	9	Accuracy of Core Automated Maintenance System (CAMS) Data	6
Backup Aircraft Inventory (BAI)	8	Officer/Enlisted Ratio	6
Temporary Duty Assignments (TDYs)	6	Aircrew Ratio	5

Several items are noteworthy. It is significant that the top three most important factors for maintenance and manpower experts were the same, although the order was different. In addition, although consensus was reached at the high to very high level of importance for *wartime sustainability up to and beyond 30 days,* this factor did not appear in Table 4.3. This could be explained by the fact that although the factor was rated at a high or very high level of importance by most respondents, those same respondents had at least ten factors which they thought were more important. Also of note is the fact that *backup aircraft inventory (BAI)* appears in the list of most important factors for maintenance and the list of least important factors for manpower. Conversely, the *accuracy of CAMS data* appeared in the list of most important factors for manpower and the list of least important factors for maintenance. *Officer/enlisted ratio* appeared in the list of least important factors for both maintenance and manpower, which was consistent with the fact that it was the only factor for which consensus was reached for the low to very low level of importance.

Comparison of Means. The next step in data analysis was a comparison of the overall means of the responses of the two populations of experts. The Wilk-Shapiro test was used to determine normality. This test produces rankit plots and a test statistic, which ranges

between zero and one. The closer the test statistic is to one, the more normal the distribution.

For this comparison, an alpha of .05 was selected and the sample size was fifty (n=50), which corresponds to the fifty factors. For these values of alpha and n, the test statistic must be greater than .953 to indicate normality. The test statistic calculated for the manpower population was .975, and the test statistic calculated for the maintenance population was .9745. Because these were both greater than .953, the Wilk-Shapiro test indicated normality for both populations.

For these two normal populations, a paired t-test was appropriate to compare the means of the responses. Results of the paired t-test are detailed in Table 4.5. Results indicated that the mean of the responses of the maintenance population was greater than the mean of the responses of the manpower population. The analysis indicated that maintenance experts generally rated factors as higher in importance than manpower experts. Once the overall means were compared and a difference was indicated, the next step was to determine which of the fifty individual factors caused this difference. To identify these factors, responses of maintenance and manpower were compared for each of the fifty factors.

TABLE 4.5 Paired T-test for Maintenance - Manpower

Paired T-test			
Mean of difference	.3320	T	2.49
Standard Error	.1334	DF	49
P-value	.0163		

Differences in Each Factor. To determine whether parametric or nonparametric tests should be used to compare the responses for each factor, each distribution of responses was tested for normality using the Wilk-Shapiro test. In order to use a parametric test, both the maintenance and manpower experts' responses for an individual factor must be from a normal distribution. No factor passed the test for normality for both distributions, therefore nonparametric tests were appropriate for all fifty factors. Results from the Wilk-Shapiro test for normality are in Appendix F.

The nonparametric rank sum test (Mann-Whitney U) was used to compare the responses for each factor. For twenty factors, significant differences existed between the responses of maintenance and manpower experts. Results of the Mann-Whitney U tests are included in Appendix G.

Three types of differences were identified. The first type of difference occurred when the responses of the two populations of experts were distinct and opposing. The second type was characterized by one population expressing a distinct opinion and the other population not expressing a

distinct opinion. The last type of difference was characterized by a majority of responses in the average range and some extreme opinions that were opposite.

Distinct/Opposite Opinions. The first type of significant difference between the maintenance and manpower responses was characterized by distinct, opposing opinions between populations. The four factors in this category are listed in Table 4.6. Maintenance experts considered three of these factors as significantly more important than manpower experts. One factor was clearly more important to the manpower experts. Stacked histograms and tables follow, with an explanation of the differences for each of these four factors. Responses of manpower experts are dark in color, and responses of maintenance experts are light in color.

TABLE 4.6 Factors With Distinct/Opposing Opinions

Factor
Backup Aircraft Inventory (BAI)
Mobility Processing/Aircraft Generating Simultaneously
Temporary Duty Assignments (TDYs)
Accuracy of Core Automated Maintenance System (CAMS) Data

Backup aircraft inventory (BAI) was the first factor for which maintenance and manpower experts had distinct, opposing opinions. Results of the Mann-Whitney U test included in Table 4.7 indicate that, at the .05 significance

level, a statistically significant difference existed in the Likert scale ratings of the maintenance and manpower experts for *backup aircraft inventory (BAI)*.

TABLE 4.7 Mann-Whitney U Table, Backup Aircraft Inventory (BAI)

Backup Aircraft Inventory (BAI) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	109.5	14	4.5	7.8
Maintenance	241.5	12	163.5	20.1
Total	351.0	26		
Two-tailed p-value for normal approximation				.0000

The histogram in Figure 4.1 confirms the fact that maintenance and manpower experts had distinct, opposing opinions. Maintenance experts clearly thought this factor was important to the determination of maintenance manpower authorization levels for the composite wing and manpower experts thought the factor was unimportant.

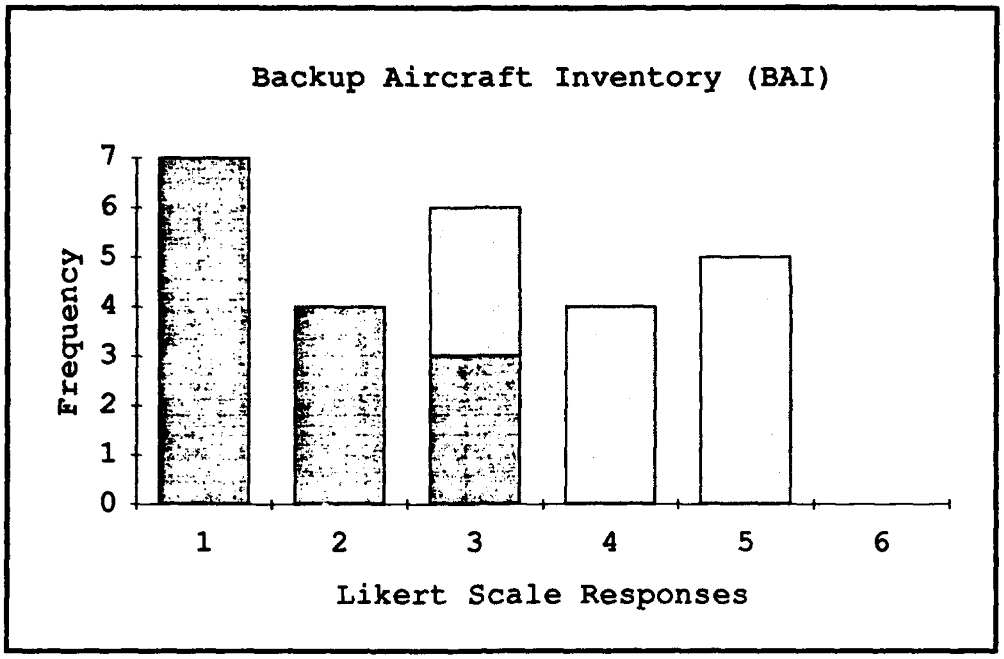


FIGURE 4.1 Histogram, Backup Aircraft Inventory (BAI)

Figure 4.1 and Table 4.7 indicate that differences in opinion exist between the maintenance and manpower experts for *backup aircraft inventory (BAI)*. This difference is probably due to the fact that units are not funded or manned to support backup aircraft inventory. Therefore, manpower experts agree that it is not an important factor in the determination of maintenance manpower authorization levels. Maintenance experts at the wing level, however, seem to believe that they do not have the necessary authorizations to perform all maintenance required on all the aircraft on station. They fail to see the distinction between primary aircraft assigned (PAA) and BAI and are only concerned with mission accomplishment.

The second factor which illustrated distinct, opposing opinions of maintenance and manpower experts was *mobility processing/aircraft generating simultaneously*. Results of the Mann-Whitney U test included in Table 4.8 indicate that, at the .05 significance level, a statistically significant difference existed in the Likert scale ratings of the maintenance and manpower experts for *mobility processing/aircraft generating simultaneously*.

TABLE 4.8 Mann-Whitney U Table, Mobility Processing/Aircraft Generating Simultaneously

Mobility Processing/Aircraft Generating Simultaneously Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	117.0	14	12.0	8.4
Maintenance	234.0	12	156.0	19.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.0002

Figure 4.2 illustrates that maintenance experts rated *mobility processing/aircraft generating simultaneously* as important in the determination of maintenance manpower authorization levels. Manpower experts, on the other hand, rated the factor as average or lower. One manpower expert did not understand what the factor meant, as illustrated by the response of "6."

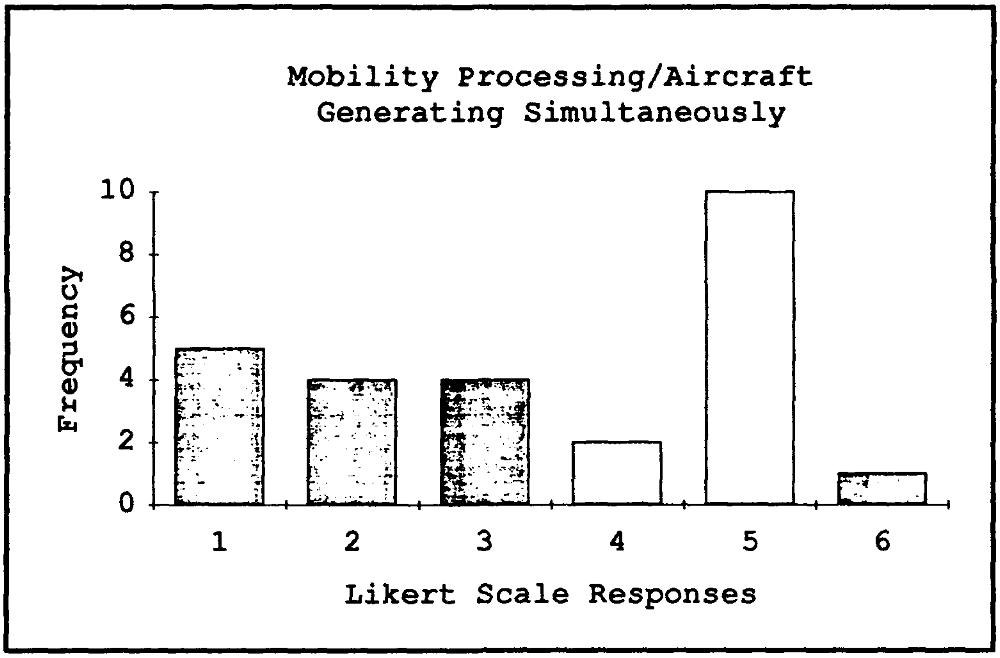


FIGURE 4.2 Histogram, Mobility Processing/Aircraft Generating Simultaneously

Figure 4.2 and Table 4.8 clearly indicate that differences in opinion existed between maintenance and manpower experts for *mobility processing/aircraft generating simultaneously*. In traditional wings, there are usually more than one squadron of each type of aircraft, and personnel are backfilled between squadrons. While one group is processing for mobility, personnel from a secondary squadron continue generating the aircraft. Because the composite wing structure eliminates this possibility, maintenance experts believe they do not have enough manpower authorizations to accomplish mobility processing and aircraft generating simultaneously. This concern is expressed in their responses.

Manpower personnel did not believe mobility processing/aircraft generating simultaneously was an important factor in the determination of maintenance manpower authorization levels. This could be due to the fact that they do not understand the constraint which the composite wing structure places on the practice of backfilling. Manpower experts may not even realize that the practice of backfilling is common.

The third factor maintenance experts rated as important and manpower experts rated as unimportant was *temporary duty assignments (TDYs)*. Results of the Mann-Whitney U test included in Table 4.3 indicate that, at the .05 significance level, a statistically significant difference existed in the Likert scale ratings of the maintenance and manpower experts.

TABLE 4.9 Mann-Whitney U Table, Temporary Duty Assignments (TDYs)

Temporary Duty Assignments (TDYs) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	94.0	13	3.0	7.2
Maintenance	231.0	12	153.0	19.3
Total	325.0	25		
Two-tailed p-value for normal approximation				.0001

Figure 4.9 illustrates the fact that maintenance experts believed that *temporary duty assignments (TDYs)* was an important factor in the determination of maintenance

manpower authorization levels. Conversely, manpower experts felt TDYs were not an important factor.

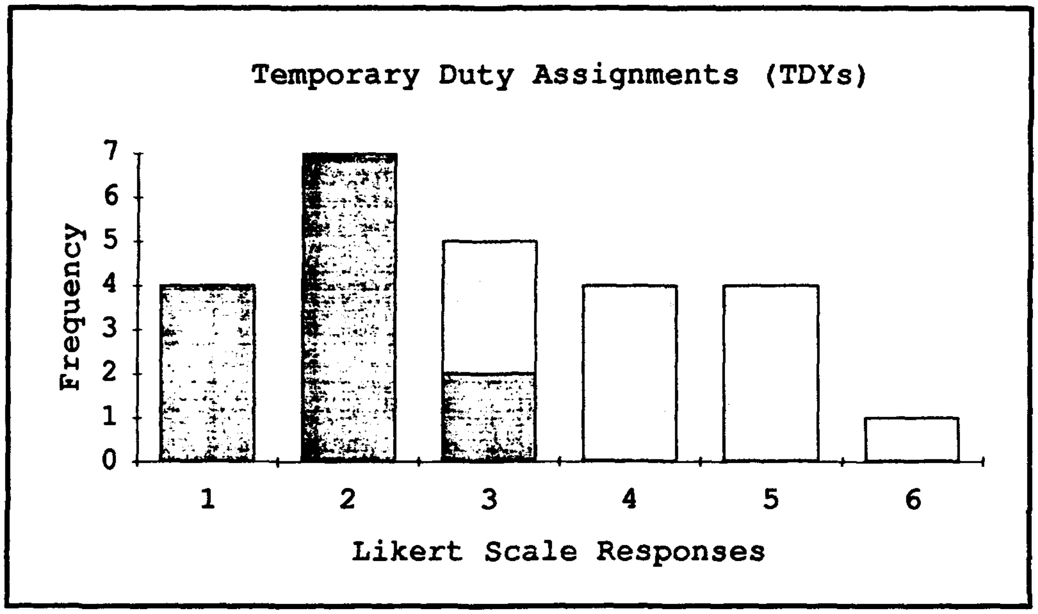


FIGURE 4.3 Histogram, Temporary Duty Assignments (TDYs)

Results indicate that differences in opinion of *temporary duty assignments (TDYs)* existed between maintenance and manpower experts. Maintenance experts believed that this factor was important in the determination of maintenance manpower authorization levels. TDYs, including professional military education (PME) and other taskings, have a direct impact on the performance of the maintenance function. An individual who is TDY is unavailable to perform his or her primary duties. Because

these TDYs are mostly unavoidable, the maintenance experts perhaps believe their units should be compensated.

Manpower experts, on the other hand, believed that TDYs are unimportant. One possible explanation is that there is no feasible way to account for TDYs in the manpower authorization process. Another possible explanation is that manpower experts do not understand the degree of the impact of TDYs on mission accomplishment.

The last factor where maintenance and manpower experts had distinct, opposing opinions was the *accuracy of Core Automated Maintenance System (CAMS) data.* In this case, however, manpower experts rated the factor as important and maintenance experts rated the factor as unimportant. Results of the Mann-Whitney U test in Table 4.10 indicate that, at the .05 level of significance, a statistically significant difference existed in the Likert scale ratings of the maintenance and manpower experts.

TABLE 4.10 Mann-Whitney U Table, Accuracy of Core Automated Maintenance System (CAMS) Data

Accuracy of CAMS Data Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	250.0	14	145.0	17.9
Maintenance	101.0	12	23.0	8.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.0019

The stacked histogram in Figure 4.4 confirms that a difference exists in the opinions of maintenance and manpower experts. Manpower experts expressed the opinion that the accuracy of CAMS data was very important to the determination of maintenance manpower authorization levels. This factor was included in the list of the most important factors for manpower experts, as seen in Table 4.4. Maintenance experts rated the factor as unimportant; this factor was in the list of bottom factors of maintenance experts, as reflected in Table 4.5.

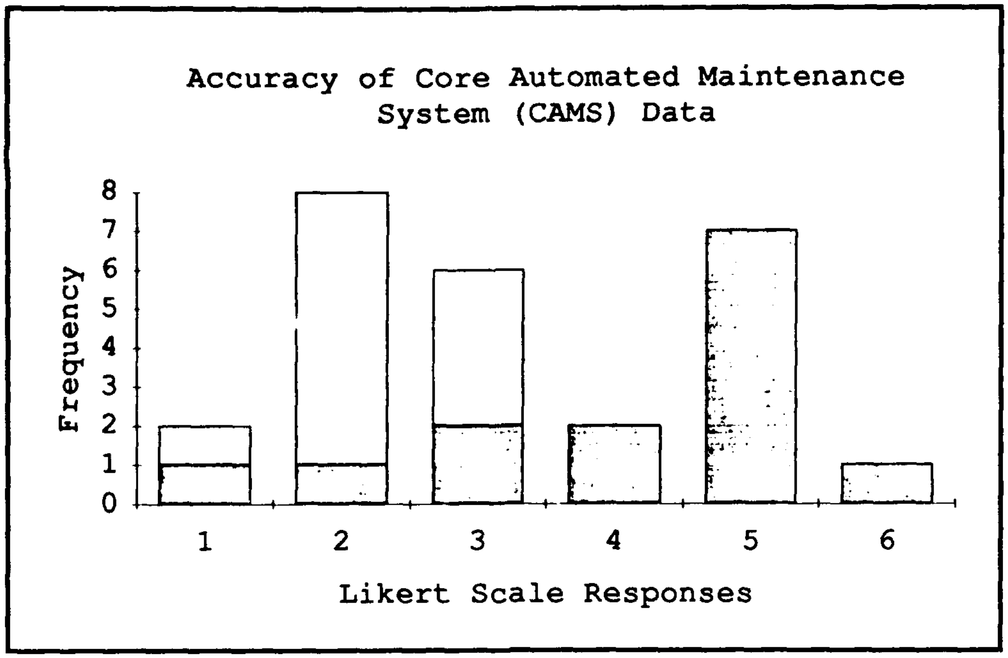


FIGURE 4.4 Histogram, Accuracy of Core Automated Maintenance System (CAMS) Data

Manpower experts rated the *accuracy of CAMS data* as an important factor in the determination of maintenance

manpower authorization levels, probably because CAMS data is a primary input to LCOM. Accurate maintenance manpower authorization levels will be established only when accurate data are input. The results indicate that maintenance experts are not aware of the direct connection between CAMS data and maintenance manpower authorization levels. CAMS, the primary maintenance data collection system, is frequently viewed as a burden and maintenance personnel do not emphasize the need for accuracy in data collection.

Distinct Opinion/No Distinct Opinion. The following four factors were rated as important in the determination of maintenance manpower authorization levels by the manpower experts: *wartime sustainability up to and beyond 30 days, average sortie duration (ASD), mean sorties between maintenance action*, and *mean time between failure (MTBF)*. Maintenance experts had no distinct opinions for these factors. It is noteworthy that *wartime sustainability up to and beyond 30 days*, which was identified as a composite wing specific factor, was rated as important by the manpower experts. Manpower experts seem to be sensitive to the needs of the composite wing. Conversely, seven maintenance experts rated this factor as important and five rated this factor as average or lower, indicating that the maintenance experts had no distinct opinion as a population. The rest of the factors, *average sortie duration (ASD), mean time between failure (MTBF)*, and *mean sorties between*

maintenance action, are all quantitative values. Manpower experts are more familiar with the use of quantitative values as inputs in manpower standards. Perhaps this familiarity explains why manpower experts rated these factors as important.

The following three factors were rated as important in the determination of maintenance manpower authorization levels by the maintenance experts: *AFSC/grade/skill level requirements, effects of multiple MDSs on backshop training,* and *mobility taskings.* Manpower experts had no distinct opinions for these factors. Two of these factors, *effects of multiple MDSs on backshop training* and *mobility taskings* were identified as composite wing specific factors. It is therefore not surprising that maintenance experts from the composite wing would rate these factors as important. Manpower experts had no distinct opinion, which could reflect a lack of understanding about the composite wing. It could also reflect disagreement within the manpower community, with some individuals believing these composite wing specific factors should be important and others believing they are not.

AFSC/grade/skill level requirements was another factor rated as important by maintenance experts. As discussed earlier, maintenance experts expressed concern about an appropriate skill level mix to meet maintenance requirements. This concern is reflected in these ratings. Manpower experts had no distinct opinion, which could

reflect the fact that manpower experts who determine authorizations do not have control over assignment of personnel to authorized positions.

MDS out of traditional MAJCOM and *availability of fuel tank buildup augmentees* were the two factors rated as unimportant by the manpower experts. Maintenance experts had no distinct opinion. The KC-135R squadron assigned to the composite wing at Mountain Home AFB is currently assigned to Air Combat Command (ACC). When Strategic Air Command was dissolved, most tankers were assigned to Air Mobility Command (AMC). The maintenance experts assigned to the tanker squadron rated *MDS out of traditional MAJCOM* as important, although the maintenance population as a whole had no distinct opinion. If the tanker maintenance experts had been excluded, this factor would have probably been rated as unimportant by both populations of experts.

The *availability of fuel tank buildup augmentees* was rated as unimportant by the manpower experts. Because this factor is not applicable to all the weapons systems assigned to the composite wing at Mountain Home AFB, maintenance experts had no distinct opinions. Only those maintenance experts affected by this factor rated it as important.

Average Ratings. The seven remaining factors of the twenty where a statistically significant difference existed between the maintenance and manpower populations reflected a majority of responses in the average range.

However, where extreme opinions were expressed, the maintenance and manpower experts' opinions were opposite. This list of factors is included in Table 4.11. Stacked histograms for these factors are included in Appendix H, and Mann-Whitney U tables are included in Appendix G.

TABLE 4.11 Factors Showing Average Opinions

Factor
Number of Time Compliance Technical Orders (TCTOs)
Maintenance Facilities Layout
Staff Positions Required by Regulation
Wartime Team Requirements
Age of Fleet
Minimum Crew Size
Maintenance Manhours Per Sortie

For the following factors, maintenance experts with extreme opinions rated them as important and manpower experts rated them as unimportant: *number of time compliance technical orders (TCTOs), maintenance facilities layout, staff positions required by regulation, wartime team requirements, age of fleet,* and *maintenance manhours per sortie.* The only factor where the extreme opinions of manpower experts were greater than the extreme opinions of maintenance experts was *minimum crew size.*

Results of LCOM. The *results of Logistics Composite Model (LCOM) simulation* was a special case which did not fit in any of the other categories but warrants

discussion. Although the *results of Logistics Composite Model (LCOM) simulation* did not yield a statistically significant difference, as illustrated in Table 4.12, a difference in opinion indeed existed.

TABLE 4.12 Mann-Whitney U Table, Results of LCOM Simulation

Results of LCOM Simulation Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	177.5	14	72.5	12.7
Maintenance	173.5	12	95.5	14.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.5715

As illustrated in Figure 4.5, six maintenance experts rated this factor as a "6", "Do Not Know." When these responses are not considered, it is clear that all manpower experts rate this factor as important or very important. Manpower experts are familiar with LCOM, the primary tool used for the determination of maintenance manpower authorization levels. Half of the maintenance experts did not know how to rate this factor, indicating that maintainers are not familiar with LCOM.

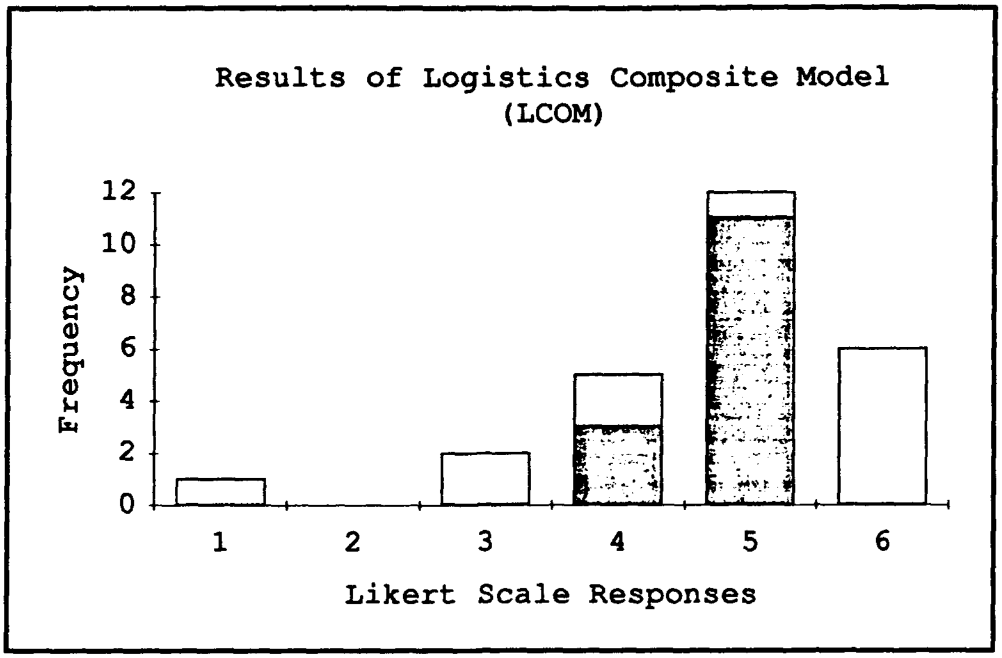


FIGURE 4.5 Histogram, Results of Logistics Composite Model (LCOM) Simulation

Reevaluation of Methodology

After analyzing the data from the second questionnaire, it became apparent that completing this research effort as a Delphi study was inappropriate. The histograms in the previous section illustrate that for a large number of factors there was a statistically significant difference. The difference in opinion is due to the fact that the two populations of experts have completely different perspectives. In a true Delphi, the population of experts is homogenous. In this study there were two distinct groups, manpower experts and maintenance experts. In a Delphi study, several iterations of the questionnaire are completed in an attempt to draw experts to a consensus by

exposing them to the answers of all experts. With two distinct groups of experts, this would probably not be of benefit. Those experts with strong enough opinions about a factor to have rated it as important or unimportant will probably not be drawn to the other end of the Likert scale. It seemed more likely that respondents would be encouraged to change their answers to a stronger level of importance or unimportance, or would be drawn to the middle of the Likert scale and a response of average.

The decision to change the methodology from a Delphi study to an opinion survey eliminated the third questionnaire. The qualitative and quantitative analysis of data collected in the first and second questionnaires was completed as planned in Chapter III. Therefore, the only change was the elimination of the third questionnaire.

Chapter Summary

This chapter presented results of the analysis of the data collected. It included identification of factors for which consensus was reached, lists of factors rated as least and most important, and detailed discussion of factors for which a statistically significant difference existed for the opinions of maintenance and manpower experts. This chapter also provided an explanation and justification of a change in methodology. The analysis presented in Chapter IV provides a basis for the conclusions and recommendations presented in Chapter V.

V. Conclusions and Recommendations

Introduction

This chapter relates the findings of this research directly to the investigative questions identified in Chapter I and presents the conclusions and recommendations about these findings. In addition, recommendations for further research are listed, including logistics research relating to the composite wing concept and direct follow-on research for this thesis.

Investigative Question 1

The first investigative question pertained to how maintenance manpower authorization levels were estimated for the composite wing at Mountain Home AFB and whether any equations were used. Because there were no established procedures or guidance for determining manpower authorization levels for a composite wing, authorizations for Mountain Home AFB were estimated from authorization levels at different units with similar weapons systems. The only available unit manning documents were from non-composite wings. The maintenance manpower authorization levels for the composite wing at Mountain Home AFB were determined by adjusting the authorization levels at non-composite wings for the number of aircraft at Mountain Home AFB. In addition, an initial estimate was made to adjust for the loss of economies of scale. No manpower equations were used.

Conclusion. This information leads to the conclusion that authorization levels were determined suboptimally. Because of the time constraints imposed by the rapid activation of the composite wing at Mountain Home AFB, estimating the maintenance manpower authorizations in this ad hoc manner was probably the only viable option at the time.

Recommendation. With time constraints now lifted, manpower personnel should reexamine the process by which maintenance manpower levels were determined for the composite wings. All important factors, including composite wing specific factors, should be accounted for in the authorization process, and the actual requirement for maintenance manpower should be determined.

Investigative Question 2

To determine which factors should be accounted for in the maintenance manpower authorization process, the second investigative question focused on the identification of factors important in the determination of authorization levels for all units.

Conclusion. Consensus was reached among the maintenance and manpower experts for the following five factors: *unit/wing mission, utilization (UTE) rate, primary aircraft assigned (PAA), aircraft maintainability,* and *scheduled maintenance requirements.* These findings indicate

that the experts believe these five factors are important in the determination of maintenance manpower authorization levels for all units.

Recommendation. Because consensus was reached between the two populations of experts for these five factors, it appears that these factors are important and should therefore be accounted for in the determination of maintenance manpower authorization levels at all units.

Investigative Question 3

In addition to the five factors listed above, factors specific to the composite wing at Mountain Home AFB were identified to answer the third investigative question.

Conclusion. Consensus was reached among maintenance and manpower experts for these two composite wing specific factors: *deployment concepts* and *wartime sustainability up to and beyond 30 days*. These findings indicate that the experts believe these two composite wing specific factors are important in the determination of maintenance manpower authorization levels at Mountain Home AFB.

Recommendation. Because findings indicate that *deployment concepts* and *wartime sustainability up to and beyond 30 days* are important, these two composite wing specific factors for Mountain Home AFB should be accounted for in the determination of their maintenance manpower authorization levels.

Investigative Question 4

The fourth investigative question addressed differences in opinions of maintenance and manpower experts. The results of this opinion survey indicate that there was agreement between the maintenance and manpower specialists on several factors, as shown in answers to investigative questions two and three. The results also indicate that many significant differences exist between the opinions of maintenance and manpower specialists.

Because the factors of greatest interest in this research effort were those specific to the composite wing, only the differences in these factors are discussed. The conclusions and recommendations resulting from the fourth investigative question follow.

Conclusions. The findings of this research indicate that differences existed in four composite wing specific factors. The first two composite wing specific factors which reflected a significant difference in opinion between maintenance and manpower experts were *mobility taskings* and *multiple MDSs*. These two factors were both in the list of top ten most important factors for the maintenance experts and were not in the list for manpower experts. The third composite wing specific factor for which a significant difference existed, *mobility processing/aircraft generating simultaneously,* was rated by the maintenance experts as important and by the manpower experts as unimportant.

Finally, *effects of multiple MDSs on backshop training* was rated by maintenance experts as important while manpower experts did not express a distinct opinion. Because significant differences of opinion exist for these four composite wing specific factors, these factors should be examined further.

It is important to attempt to understand why the differences in opinion exist between maintenance and manpower experts. These differences could be attributed to the fact that maintenance and manpower specialists have little exposure to each others' jobs. Education in this area is important.

Recommendations. Manpower experts should examine the impact of *mobility taskings* and *multiple MDSs* on maintenance manpower requirements in order ensure the needs of the composite wing at Mountain Home AFB are being met. Manpower experts should also determine whether *mobility processing/aircraft generating simultaneously*, unique to the composite wing, demands increases in maintenance manpower authorizations. Because of the rapid deployment requirements of the composite wing, shortchanging manpower requirements by ignoring the impact of this factor could critically impair the composite wing deployment capabilities. Finally, the impact of *effects of multiple MDSs on backshop training* needs to be evaluated to ensure

increased maintenance training requirements are not detrimental to meeting maintenance requirements.

Difference in opinions between maintenance and manpower experts were not limited to composite wing specific factors, and therefore recommendations should not be limited to composite wing specific factors. Other recommendations are discussed. The researchers believe education is the key to decreasing differences of opinion.

Maintenance experts should take the responsibility to be familiar with the inputs they have into the manpower authorization process. Specifically, maintenance experts should recognize that the CAMS maintenance data collection system is a direct input to the authorization process. They should not shortchange themselves by providing inaccurate data, as is often the case. In addition, maintenance experts should be exposed to LCOM early in their careers. Understanding the system and playing an active role in providing accurate inputs will increase confidence in the maintenance manpower authorization process. Confidence in the process will also reduce dissatisfaction with manpower authorization levels.

Manpower experts should also become more educated about the maintenance requirements of the units. They should understand the unique mission and concepts of the composite wing, and the impact on maintenance manpower authorization levels. Particular attention should be placed on the

composite wing specific factors which were rated as important by the maintenance experts, as discussed above.

In addition, manpower experts must be aware of the effect of additional requirements on the maintenance effort. Two examples of additional requirements which have a great impact on maintenance are *temporary duty assignments (TDYs)* and *backup aircraft inventory (BAI)*. Manpower specialists may be unable to account for these factors in the current maintenance manpower authorization system, but should be sensitive to the impact of these factors.

Finally, communication between maintenance and manpower specialists should be increased. By teaching each other as much as possible about how authorizations are developed and how these authorizations impact the mission, each community will be able to complete its respective job more efficiently and effectively.

Investigative Question 5

The answer to the final investigative question consists of the factors which should be considered in the development of maintenance manpower authorization levels at Mountain Home AFB if changes were made to the current authorization process. Although the findings indicate that there are many factors which are important, particularly the factors where consensus was reached, there were three factors for which consensus was extremely high.

Conclusion. Three factors where consensus was reached are *utilization (UTE) rate, deployment concepts,* and *primary aircraft assigned (PAA).* These factors were also listed as the top three most important factors by both the maintenance and manpower experts.

Recommendation. Because the level of consensus was so high for *utilization (UTE) rate, deployment concepts,* and *primary aircraft assigned (PAA)*, the authorization process should account for these three factors, at a minimum.

Recommendations for Further Research

The literature review revealed that the composite wing structure is a new subject area for graduate level research. Discussions with other logisticians throughout the development of this thesis indicate that there are composite wing issues in every logistics discipline which could benefit from research. In addition, this thesis has potential for specific follow-on research. The following sections include general recommendations for logistics research concerning the composite wing structure, and specific recommendations for follow-on research for this thesis.

Possible Research for Composite Wing Logistics.

1. Mobility. Research could be conducted to determine whether the composite wings can meet their unique mobility requirements. One specific topic for research would be to

determine whether the composite wings have the necessary resources to mobilize. Another focus would be to determine whether a composite wing which was given all the resources necessary would have the ability to deploy in the time allotted.

2. Transportation. Researchers could address the unique transportation requirements of the composite wings. Are organic and non-organic resources capable of deploying and supporting the various possible scenarios for which a composite wing could be tasked?

3. Supply. The impact of multiple MDSs on the supply system could be examined to determine whether the composite wings can be supported by the present supply system. Specific areas of interest would include fuels, bench stock, and spare parts.

4. Munitions. Again, the impact of multiple MDSs could be studied. The specific impact on munitions storage, maintenance and loading are all worthy of examination.

5. Logistics Plans. Another area for potential research is the feasibility of current logistics plans for the composite wings. Is there an optimal fashion to build logistics plans? What is the impact of building plans to support every possible contingency? Is there an optimal number of logistics plans?

Potential Follow-on Research for this Thesis.

1. The results of this research could be verified for the composite wing at Mountain Home AFB by conducting repeat surveys of the same participants. A different population of experts could also be used. In addition, the same study could be performed for a different composite wing and the results could be compared.

2. Using the factors identified in this survey, researchers could create a model to determine maintenance manpower authorization levels. The results of this model could be compared with LCOM results.

3. Researchers could conduct a true Delphi to expose maintenance and manpower experts to each others' opinions. This Delphi could be conducted on two separate groups, maintenance experts and manpower experts, simultaneously. The intent would be to bring two different homogenous groups to consensus.

4. Another study could attempt to improve the level of understanding between maintenance and manpower experts. This research could involve a pretest which determines experts' opinions, training for the sample population, and a post test to determine how opinions are affected by the training.

4. Researchers could perform a cost analysis of the loss of economies of scale created by activation of composite wings. This analysis could focus on increased cost for maintenance actions, specifically addressing

increased cost of training maintenance personnel for multiple MDSs, cost of TDYs, costs incurred due to increases in overhead staff positions.

Conclusion

It is evident that maintenance experts at the composite wing at Mountain Home AFB believe there are specific factors which directly impact the requirements for maintenance manpower. Manpower experts, however, do not reflect this concern. This difference in opinion must be resolved to the satisfaction of both communities. Education and increased communication will facilitate this resolution.

Appendix A: Definitions

Definitions AFR 26-1, Manpower: Manpower Policies and Procedures, Determining Manpower Requirements, defines several terms used in the manpower calculation process. These definitions establish a clear basis for discussion of manpower issues.

1. Manpower requirement: The specific number and type of people needed to accomplish a job, workload, mission, or program.

2. Funded requirements: Approved requirements accepted for inclusion in the resources requested in the budget and subsequently approved by Congress.

3. Unfunded requirements: Approved requirements for authorized workloads or projects which are in excess of available resources.

4. End Strength: The count of military and civilian positions which the Air Force needs to have funded in each year of the Five Year Defense Program to accomplish all approved missions.

5. Manpower authorization: The detail which defines each position in terms of its function, organization, location, skill, grade, and other appropriate characteristics which commands use to extend end strength resource to their units.

Appendix B: List of Experts

Brig Gen David J. McCloud	366 WG/CC
Col Jerrold K. Callen	366 WG/CV
Col William R. Davis	366 LG/CD
Col Robert L. Hart	366 LG/CC
Col Robin E. Scott	366 OG/CC
Col James S. Severs	HQ ACC/XPM
Lt Col Frank W. Clawson	391 FS/CC
Lt Col Greg Davis	HQ ACC/XPMRM
Lt Col John F. Gaughan II	22 ARS/CC
Lt Col William C. McGammon	389 FS/MA
Lt Col Larry D. New	390 FS/CC
Lt Col Donald L. Oukrop	389 FS/CC
Lt Col Ward E. Tyler	366 MS/CC
Maj Alan M. Brown	34 BS/MA
Maj Robert E. Clayton	390 FS/MA
Maj Louis M. Johnson, Jr.	366 LSS/CC
Maj Michael J. Lyons	22 ARS/MA
Capt William R. Dudley	366 WG/MO
Capt Gregory J. Hoffman	366 MS/MA
Capt Martin P. Nee	391 FS/MA
Capt John Schneider	HQ ACC/XPME
Lt Michael Payne	HQ ACC/XPME
CMSgt Charles Chubb	391 FS/MA
CMSgt Joseph Clay	366 MS/CCQS
CMSgt Gary Huston	389 FS/MA
CMSgt Steven D. Meredith	366 MS/CCQS
SMSgt Louis Barlow	390 FS/MA
SMSgt Steve Brown	HQ ACC/XPMRM
SMSgt John M. Jones	22 ARS/MA
SMSgt Alan Rose	HQ ACC/XPME
SMSgt Stanley Stroney	HQ ACC/XPME
MSgt Alan Bishop	HQ ACC/XPME
MSgt Bill Godar	HQ ACC/XPMRM
MSgt Desmond Osborne	HQ ACC/XPME
MSgt Thomas Sackett	HQ ACC/XPME
MSgt Michael Stevens	HQ ACC/XPME
MSgt Gary Upchurch	HQ ACC/XPMRM
SSgt John Edgar	HQ ACC/XPME
Mr Howard Beizer	HQ ACC/XPMRM
Mr Stacey Fenner	HQ ACC/XPME
Mr Gary Myers	HQ ACC/XPMRM
Ms Betty Roland	366 WG/MO
Ms Sondra Sandkulla	HQ ACC/XPME
Mr Phil Stone	HQ ACC/XPME
Ms Debbie VanSciver	HQ ACC/XPME
Mr Don White	HQ ACC/XPME

Appendix C: Round One Delphi Questionnaire

11 Feb 94

AFIT/LA
2950 P Street
Wright-Patterson AFB, OH 45433-7765

Participant
Office Symbol
Street Address
Base, State, Zip Code

Dear Participant

Thank you for participating in this Air Force Institute of Technology (AFIT) Delphi questionnaire. Capt Stella Smith and Capt Cristina Vilella are performing this research to identify factors that are significant in the determination of maintenance manpower authorization levels for the composite wing at Mountain Home Air Force Base (AFB), Idaho, by attempting to reach a consensus among those most familiar with the issue.

You were selected to participate in this research effort because your experience and knowledge qualify you as an expert. Because the number of participants is small, your response is extremely important. Personal opinions and comments are being solicited from both manpower and maintenance experts. Once the results of the first questionnaire are compiled, you will receive a second questionnaire, which will seek your opinions on the results of the first questionnaire in an attempt to reach a consensus. You will be provided a summary of the results of this research.

The questionnaire is intended to stimulate your thinking about different aspects of the manpower authorization issue and you may comment on anything you feel relates to the questions. Feel free to attach additional comments if the space provided is insufficient.

The number in the upper-right hand corner of the questionnaire is for control purposes only. Your individual response will not be attributed to you personally. Complete anonymity will be ensured for all participants. If you have any questions, please contact Capt Smith at (513)255-7777

(DSN 785-7777), extension 2342, or Capt Vilella at extension 2381.

Please complete the survey and return it in the enclosed envelope within one week of receipt. We appreciate your willingness to work this into your schedule; your expertise is invaluable to the success of this research.

Sincerely

PHILLIP E. MILLER, Lt Col, USAF
Associate Dean
Graduate School of Logistics and
Acquisitions Management

Attachment:
1. Delphi Questionnaire

ID # ____

1. What is your duty AFSC? (for example: 4024(or 21A3)--aircraft maintenance officer)

2. How many total years of job experience in aircraft maintenance/manpower do you have?

3. What is your duty title? How long have you been assigned to your current position?

ID # ____

4. List and briefly explain factors you consider important in the determination of maintenance manpower authorization levels. Why do you think these factors are important? Please list in order of importance, with the first factor being the one you consider the most important.

ID # ____

5. Are there any factors above and beyond the ones you listed in the previous question that are specific to the organizational structure and mission of the composite wing at Mountain Home AFB? Provide a brief explanation and reasons why you think these factors are important. Please list in order of importance, with the first factor listed being the one you consider most important.

ID # ____

6. Are there any other issues related to the determination of maintenance manpower authorization levels at Mountain Home AFB that you feel are important and have not been directly addressed in this questionnaire? If so, please discuss the issues and why you believe they are important in this determination.

Appendix D: Round Two Delphi Questionnaire

15 Apr 94

AFIT/LA
2950 P Street
Wright-Patterson AFB, OH 45433-7765

Participant
Office Symbol
Street Address
Base, State, Zip Code

Dear Participant

Thank you for responding to our first Air Force Institute of Technology (AFIT) Delphi questionnaire which asked you to identify the factors you consider important in the determination of maintenance manpower authorization levels, including those factors specific to the composite wing at Mountain Home AFB. All the factors identified by yourself and other maintenance and manpower experts were consolidated into this second questionnaire, which will help us determine the level of importance of each factor.

Because the number of participants is small, your response is critical. Once the results of the second questionnaire are analyzed, you may receive a third questionnaire to attempt to increase the level of consensus.

Your individual response will not be attributed to you personally. Complete anonymity will be ensured for all participants. If you have any questions, please contact Capt Stella Smith at DSN 785-7777 or (513) 255-7777, extension 2342, or Capt Cristina Vilella at extension 2381. Please complete the survey and return by fax to DSN 986-7988

or (513) 476-7988 by 22 Apr 94. We appreciate your willingness to work this into your schedule; your expertise is invaluable to the success of this research.

Sincerely

PHILLIP E. MILLER, Lt Col, USAF
Associate Dean
Graduate School of Logistics and
Acquisitions Management

Attachment:
1. Delphi Questionnaire

ID#_____

The following factors have been identified by you, the experts, as being important in the determination of aircraft maintenance manpower authorization levels for the composite wing at Mountain Home Air Force Base (AFB). The purpose of this survey is to determine the *level of importance* you place on each factor. Please return by FAX to Capt Cristina Vilella and Capt Stella Smith, AFIT/LAA, DSN 986-7988 or (513)476-7988 by **22 Apr 94**.

The factors have been broken down into five groups of ten factors for your convenience only. There is no significance to the groups or to the order the factors have been placed within each group. Please rate the level of importance of each factor in the space provided using the following scale:

1.	**2.**	**3.**	**4.**	**5.**	**6.**
Very Low	Low	Average	High	Very High	Do Not Know

1. Utilization (UTE) rate _____

2. Maintenance concept _____

3. Aircraft maintainability _____

4. Primary aircraft assigned (PAA) _____

5. Deployment concepts _____

6. Wing organizational concept _____

7. Aircrew ratio _____

8. Accuracy of Core Automated Maintenance System (CAMS) data _____

9. Munitions rates of buildup _____

10. Number of Time Compliance Technical Orders (TCTOs) (modifications) _____

ID#_____

1. Very Low	2. Low	3. Average	4. High	5. Very High	6. Do Not Know

1. Geographically separated unit (GSU) _____

2. Mean time between failures (MTBF) _____

3. Mobility taskings _____

4. Unit/wing mission (peacetime vs wartime, combat vs training) _____

5. Temporary duty assignments (TDYs) (mobility taskings and PME) _____

6. Operating environment/base location _____

7. Wartime team requirements (Aircraft Battle Damage Repair (ABDR), decontamination team, etc.) _____

8. Types of munitions _____

9. Type of mission design series (MDS) _____

10. Age of fleet _____

1. Very Low	2. Low	3. Average	4. High	5. Very High	6. Do Not Know

1. Average sortie duration (ASD) _____

2. Manpower standards _____

3. Parts levels _____

4. Scheduled maintenance requirements _____

5. Effects of multiple MDSs on backshop training _____

6. Wartime munitions load and expenditure rates _____

7. Minimum crew size _____

8. Wartime sustainability up to and beyond 30 days _____

9. Maintenance manhours per sortie _____

10. Aircraft turn time _____

ID#_____

1. Very Low	2. Low	3. Average	4. High	5. Very High	6. Do Not Know

1. Funded flying hours _____

2. Backup aircraft inventory (BAI) _____

3. Mobility processing (people/equipment) and aircraft generating simultaneously _____

4. Officer/enlisted ratio _____

5. Shared resources (personnel/equipment) between MDSs _____

6. Maintenance facilities layout _____

7. Results of Logistics Composite Model (LCOM) simulation _____

8. Support equipment available _____

9. Mean sorties between maintenance action _____

10. Reliability and Maintainability (R&M) improvements _____

1. Very Low	2. Low	3. Average	4. High	5. Very High	6. Do Not Know

1. Multiple MDSs _____

2. Maintenance policies _____

3. Manhour availability factors _____

4. MDS assigned out of traditional major command _____

5. AFSC/grade/skill level requirements _____

6. Staff positions required by regulation _____

7. Additional aircraft systems (LANTIRN, ECM pods) _____

8. Maintenance fix rates _____

9. Availability of fuel tank buildup augmentees _____

10. Minimum required specialists _____

ID# _____

Please rank order the **top ten** factors in order of importance with the first being the **most** important.

1. ______________________________ (most important)

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

9. ______________________________

10. ______________________________

Please rank order the **bottom five** factors in order of importance with the first being the **least** important

1. ______________________________ (least important)

2. ______________________________

3. ______________________________

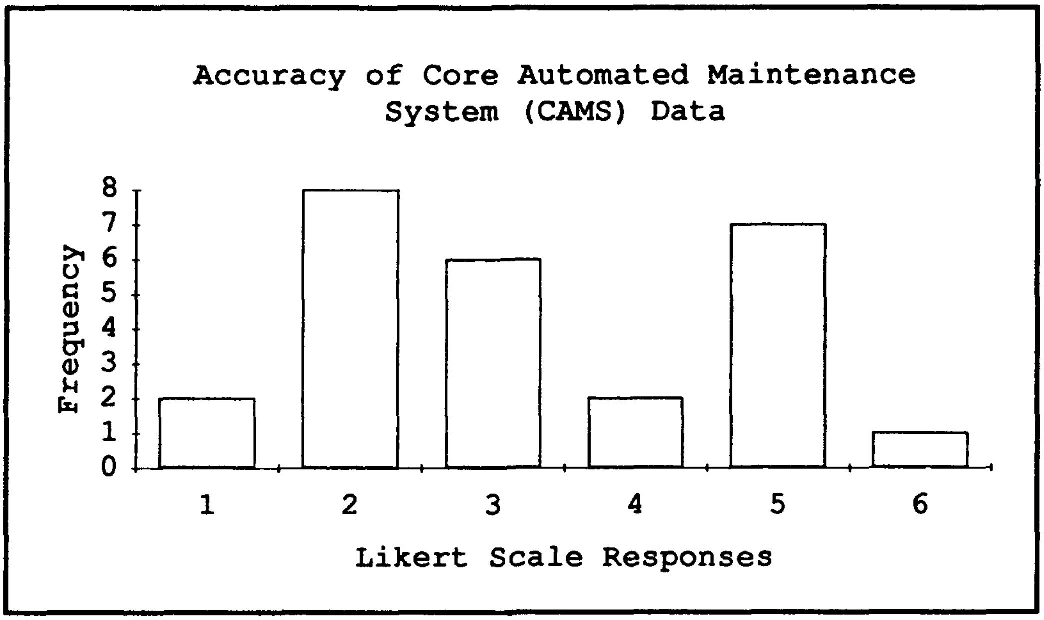
4. ______________________________

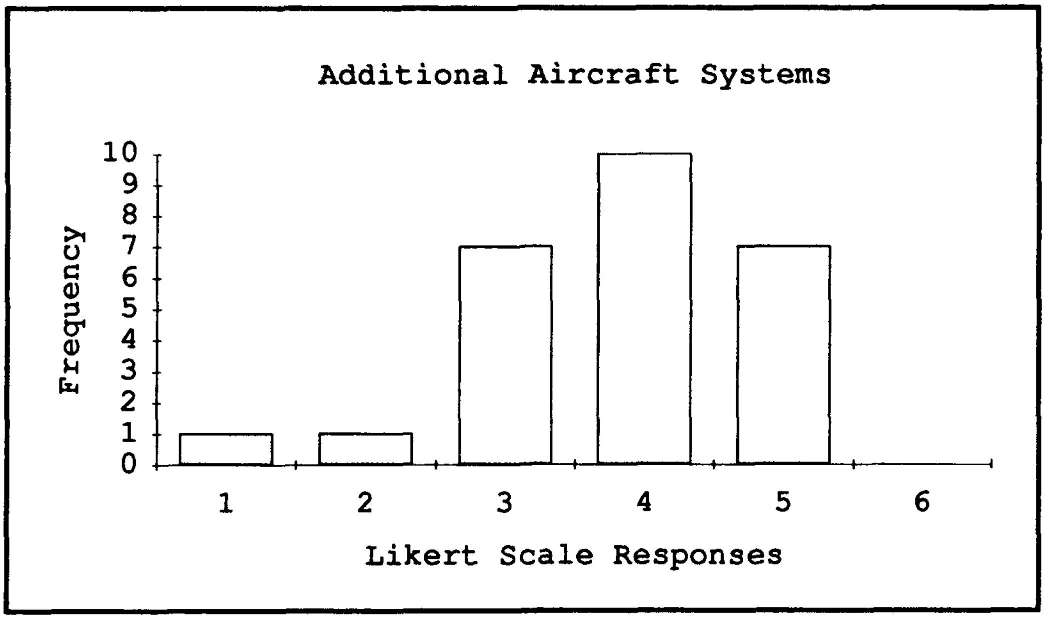
5. ______________________________

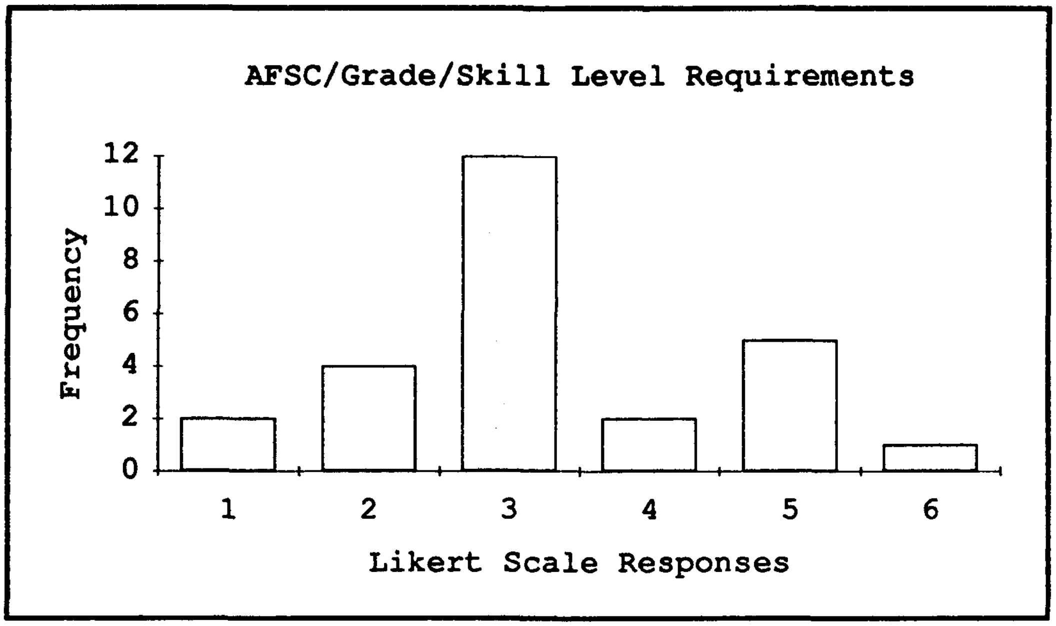
Return by **22 Apr 94**:

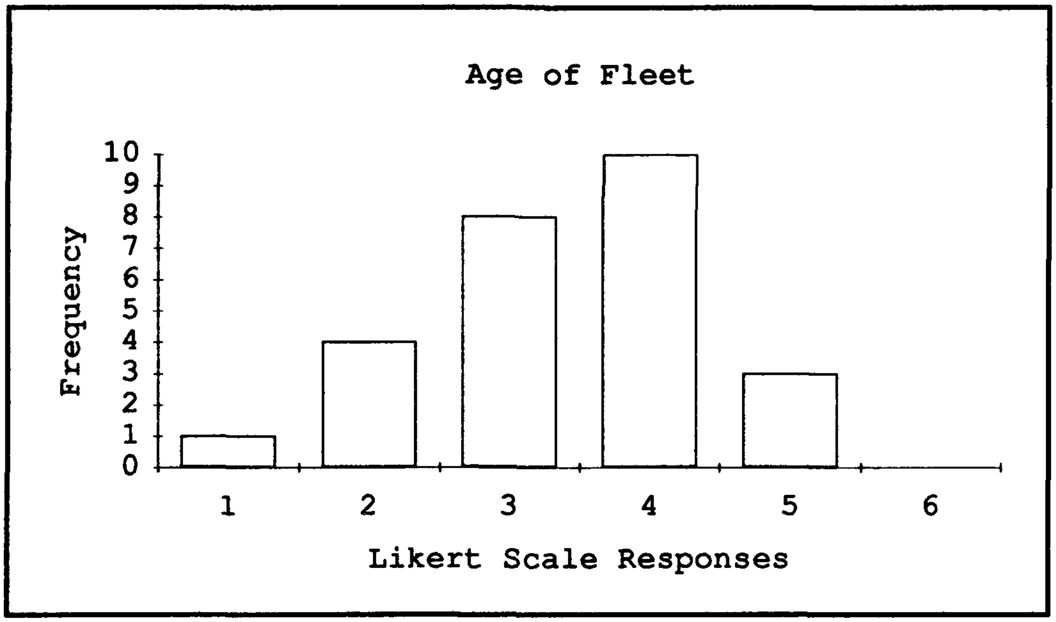
Capt C. Vilella/Capt S. Smith
AFIT/LAA
FAX: DSN 986-7988 or (513)476-7988

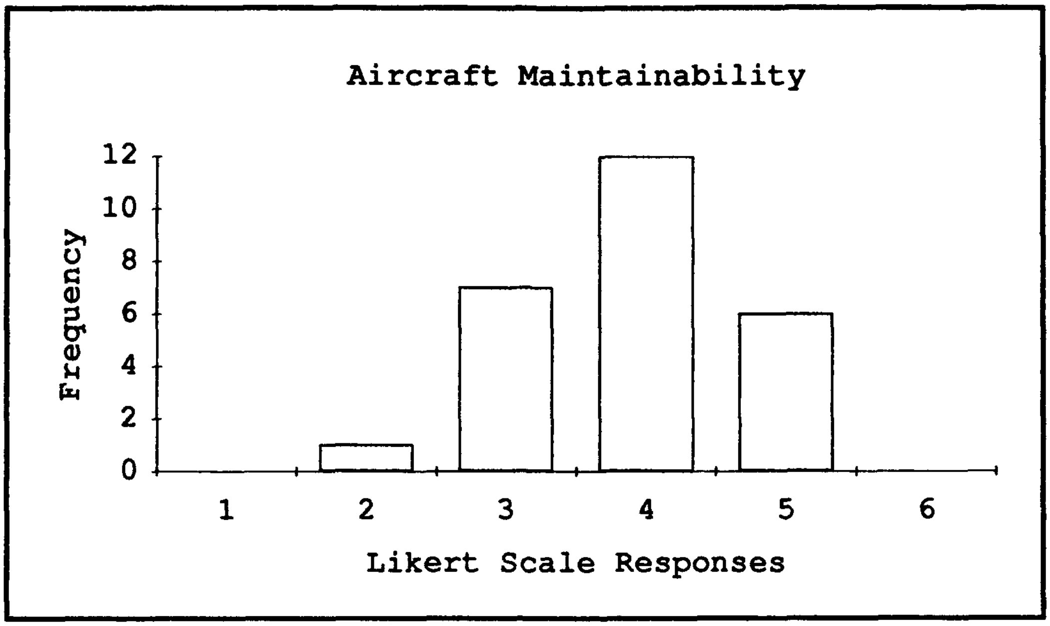
Appendix E: Histograms for Determination of Consensus

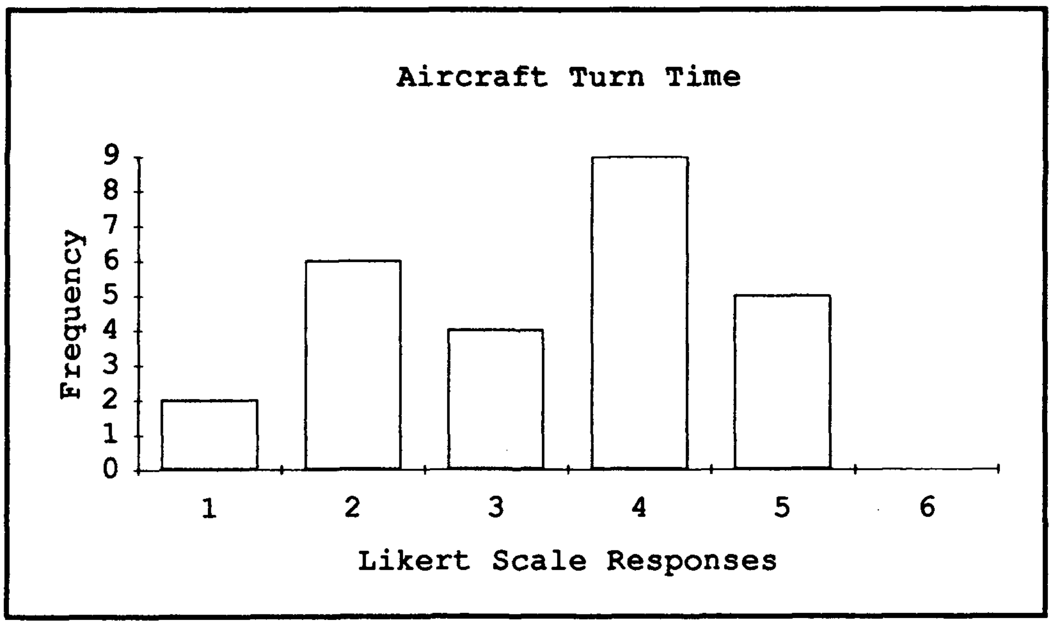


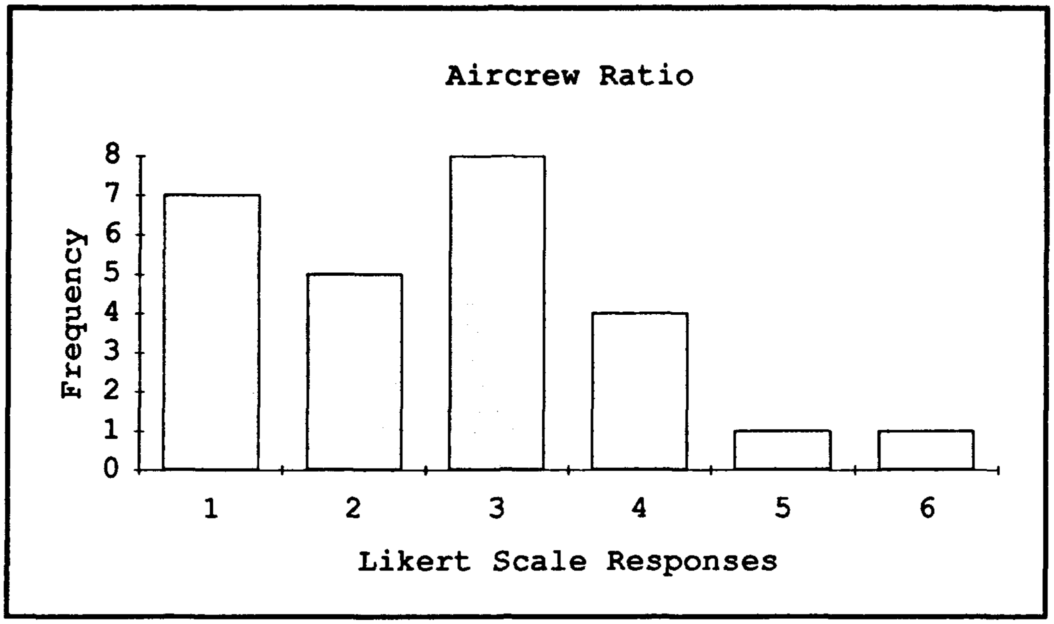


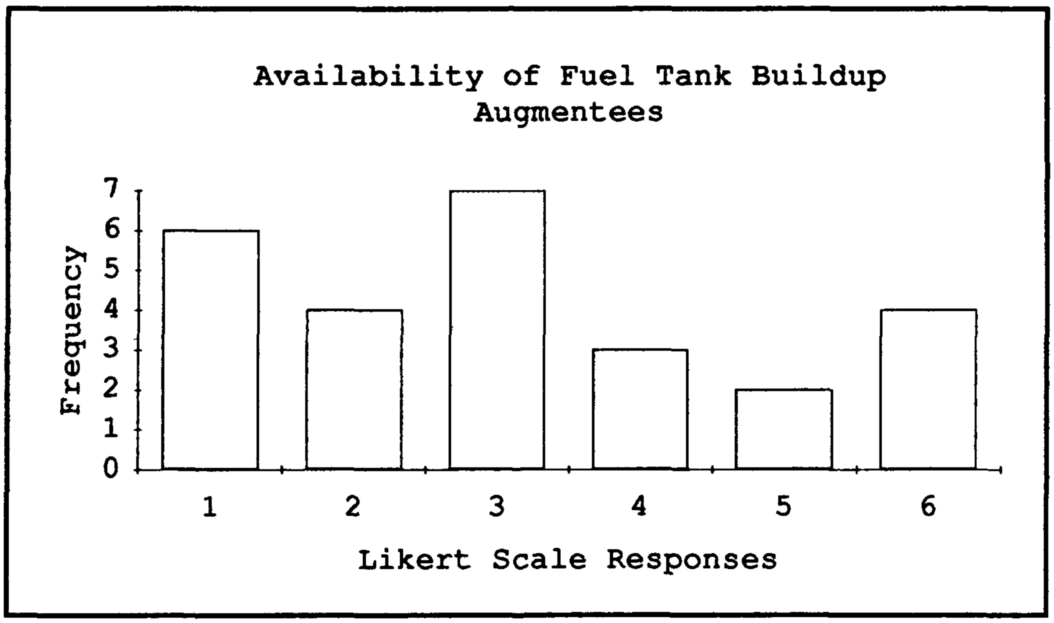

AFSC/Grade/Skill Level Requirements
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

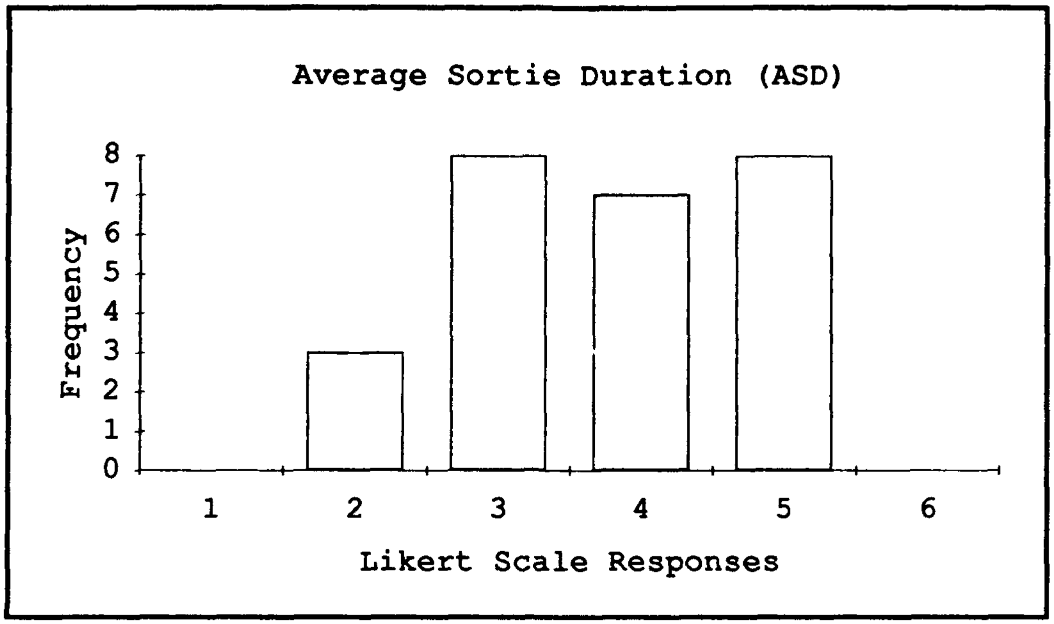

Age of Fleet
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

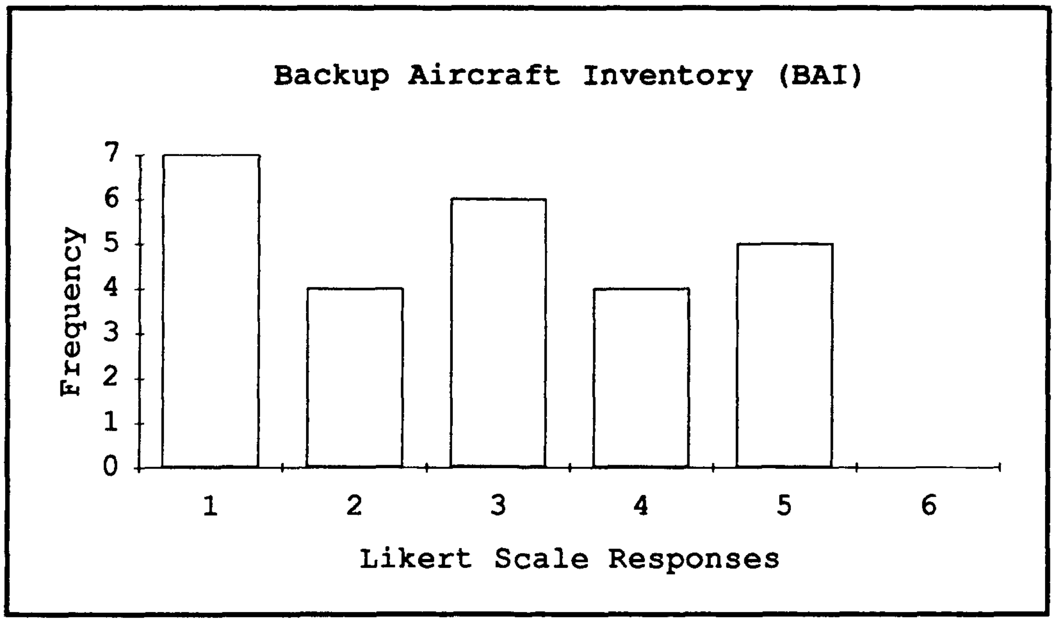

Aircraft Maintainability
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

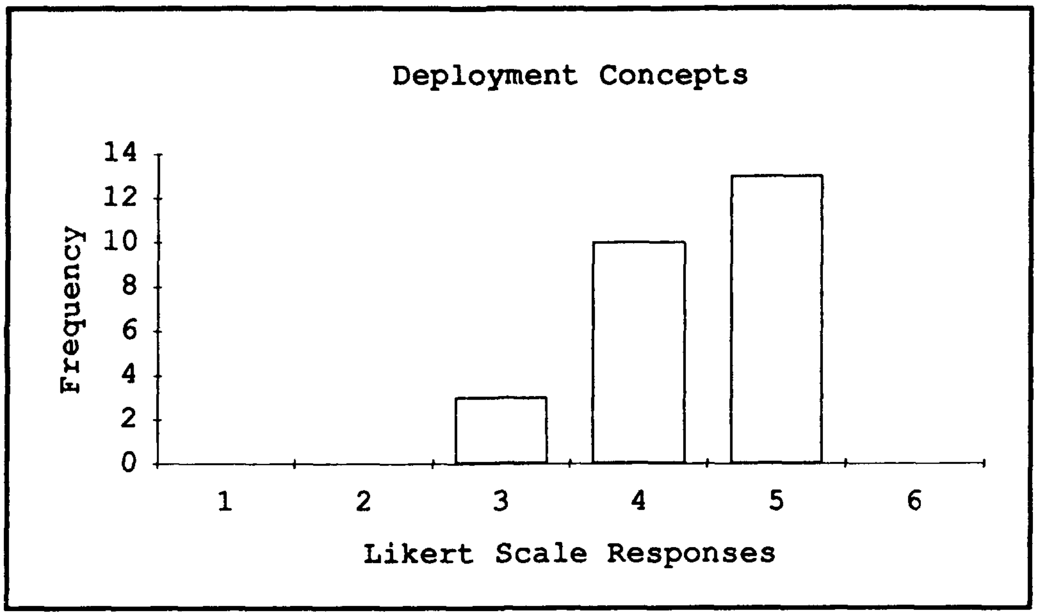

Aircraft Turn Time
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

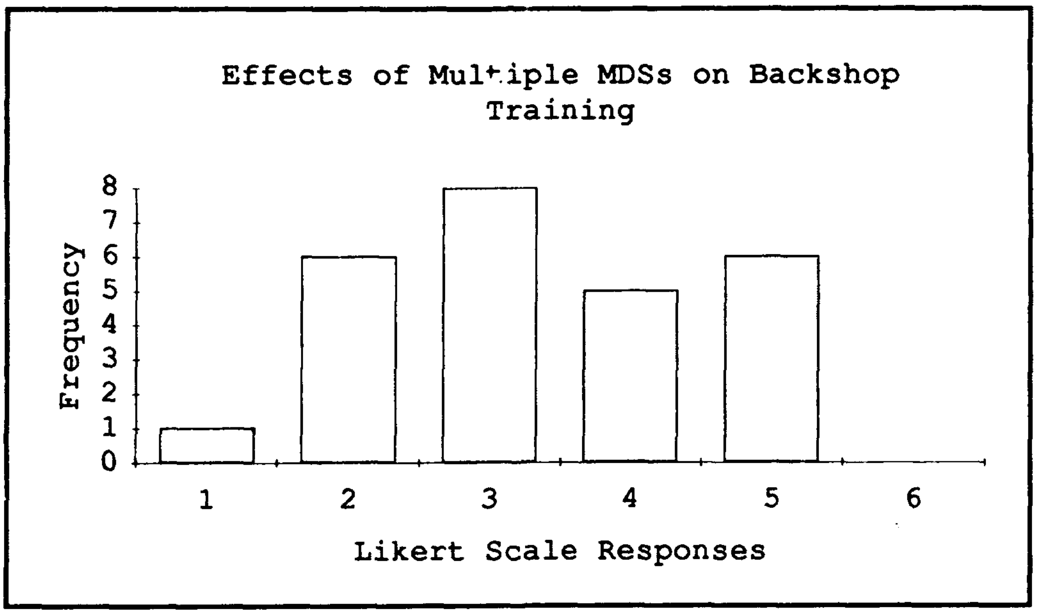

Aircrew Ratio
Frequency
0
1
2
3
4
5
6
7
8
1
2
3
4
5
6
Likert Scale Responses

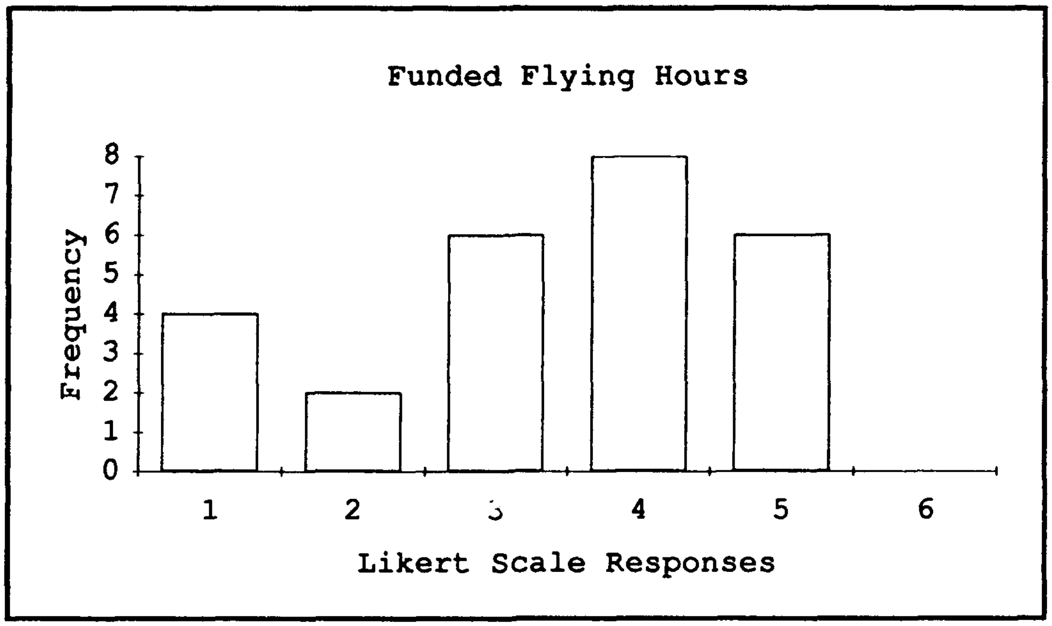

Availability of Fuel Tank Buildup Augmentees
Frequency
0
1
2
3
4
5
6
7
1
2
3
4
5
6
Likert Scale Responses

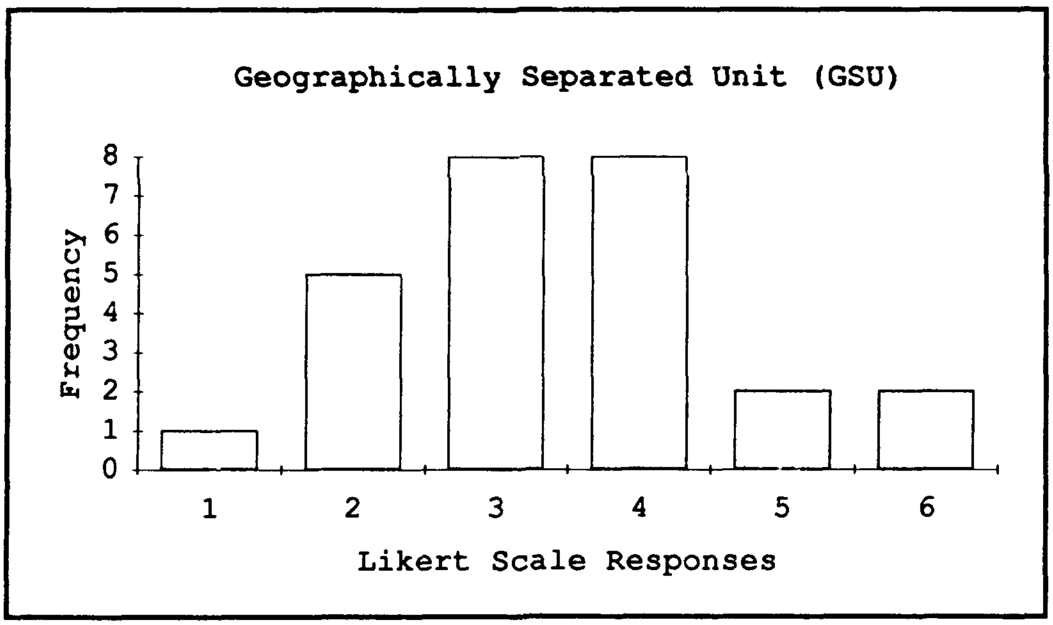

Average Sortie Duration (ASD)
Frequency
0
1
2
3
4
5
6
7
8
1
2
3
4
5
6
Likert Scale Responses

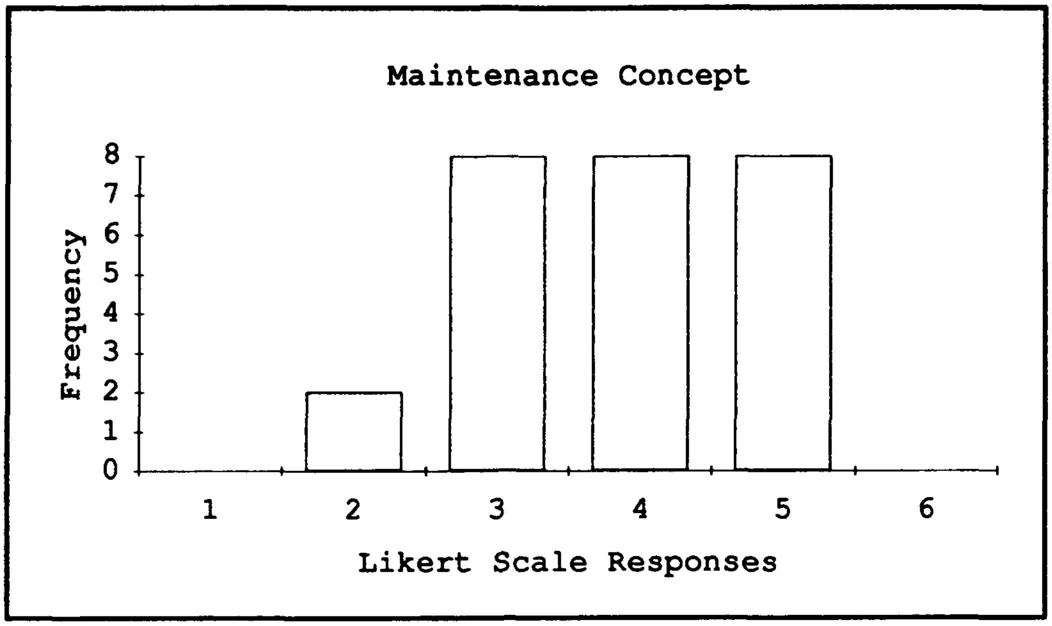

Backup Aircraft Inventory (BAI)
Frequency
0
1
2
3
4
5
6
7
1
2
3
4
5
6
Likert Scale Responses

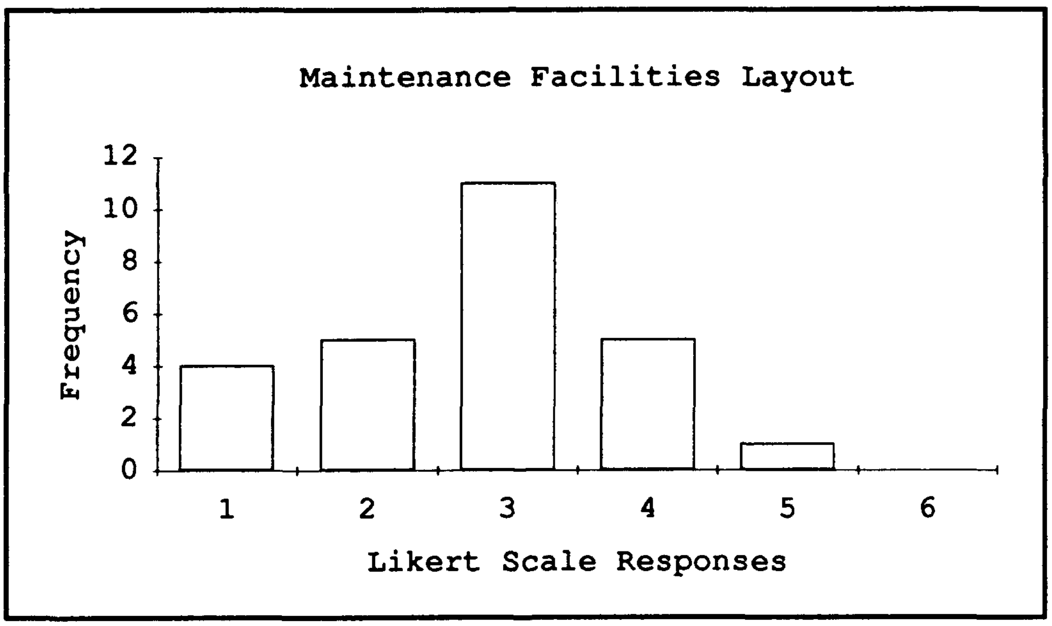

Deployment Concepts
14
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
Likert Scale Responses

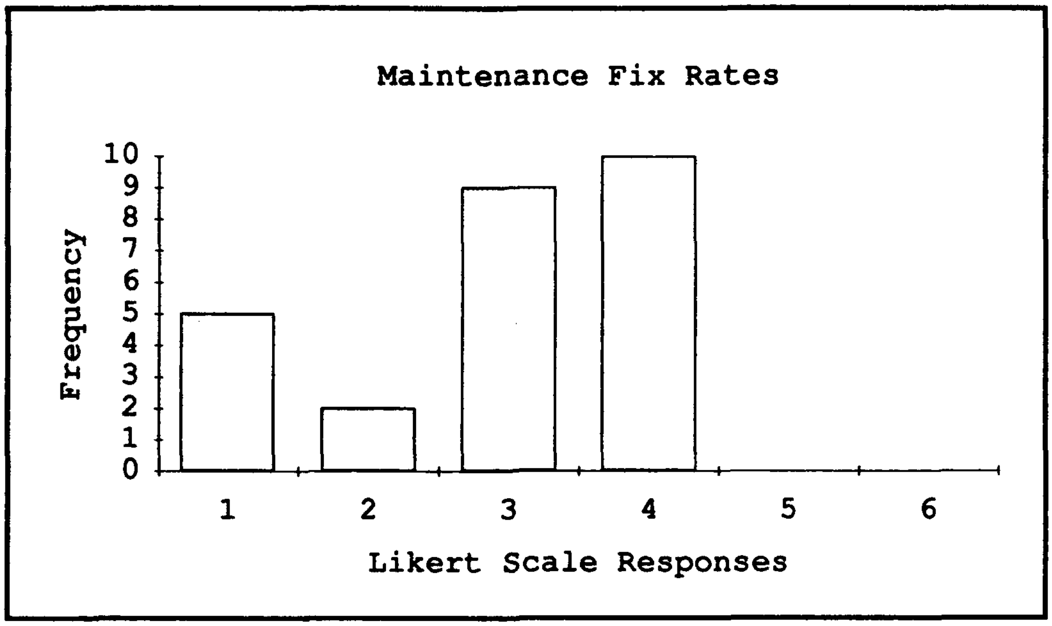

Effects of Multiple MDSs on Backshop Training
8
7
6
5
4
3
2
1
0
Frequency
1
2
3
4
5
6
Likert Scale Responses

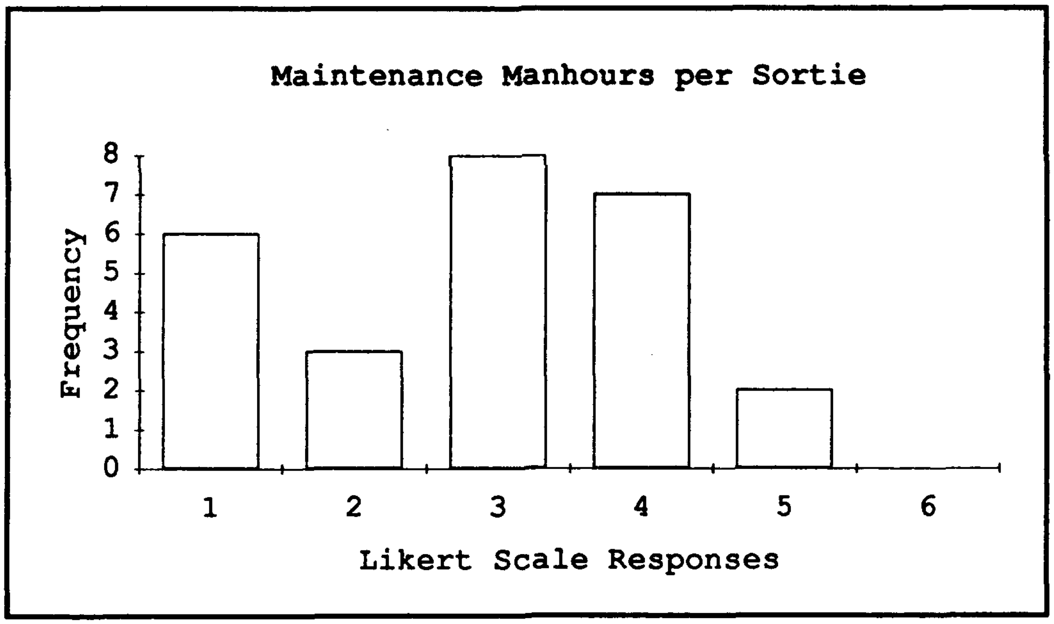

Funded Flying Hours
Frequency
8
7
6
5
4
3
2
1
0
1
2
4
5
6
Likert Scale Responses

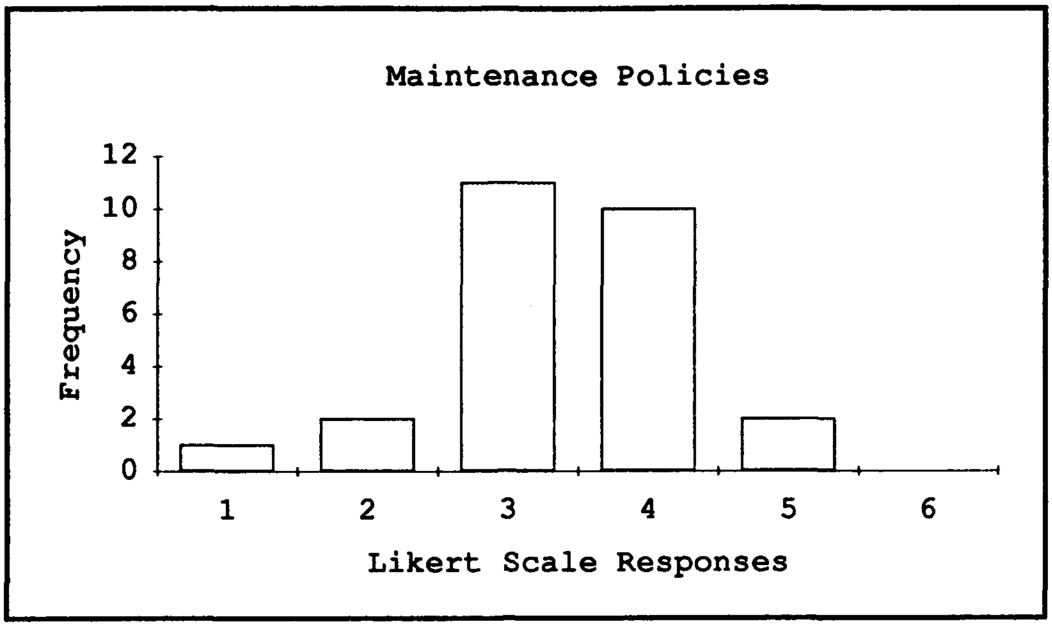

Geographically Separated Unit (GSU)
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

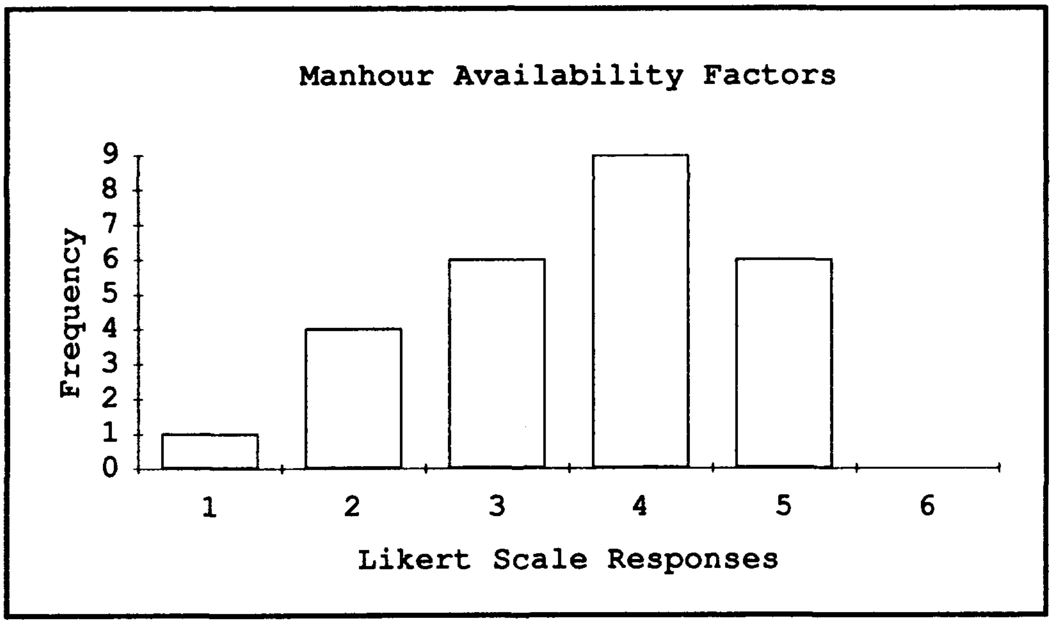

Maintenance Concept
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

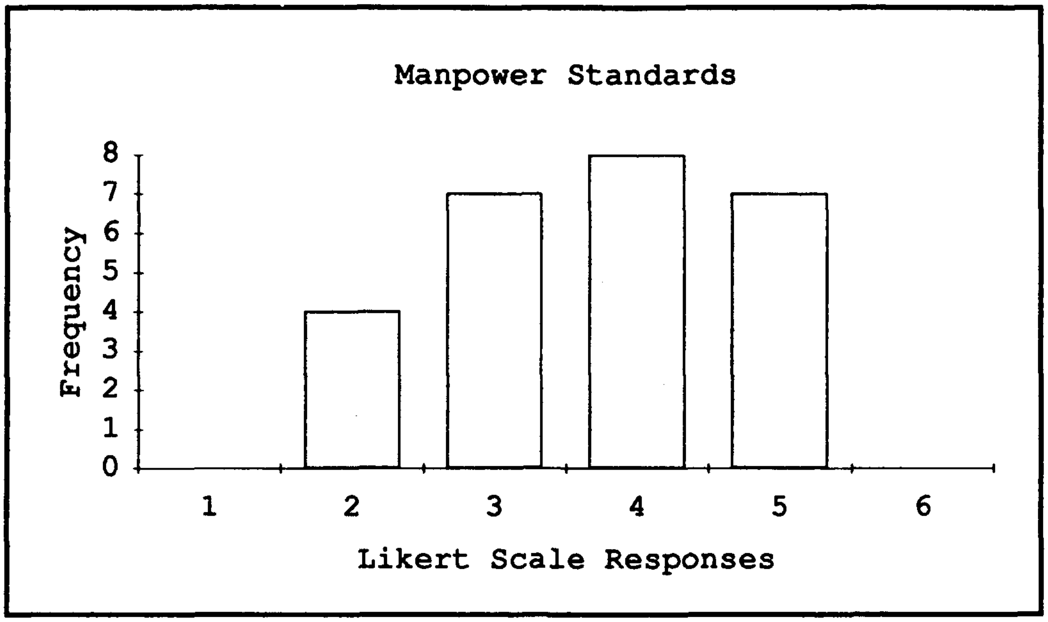

Maintenance Facilities Layout
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

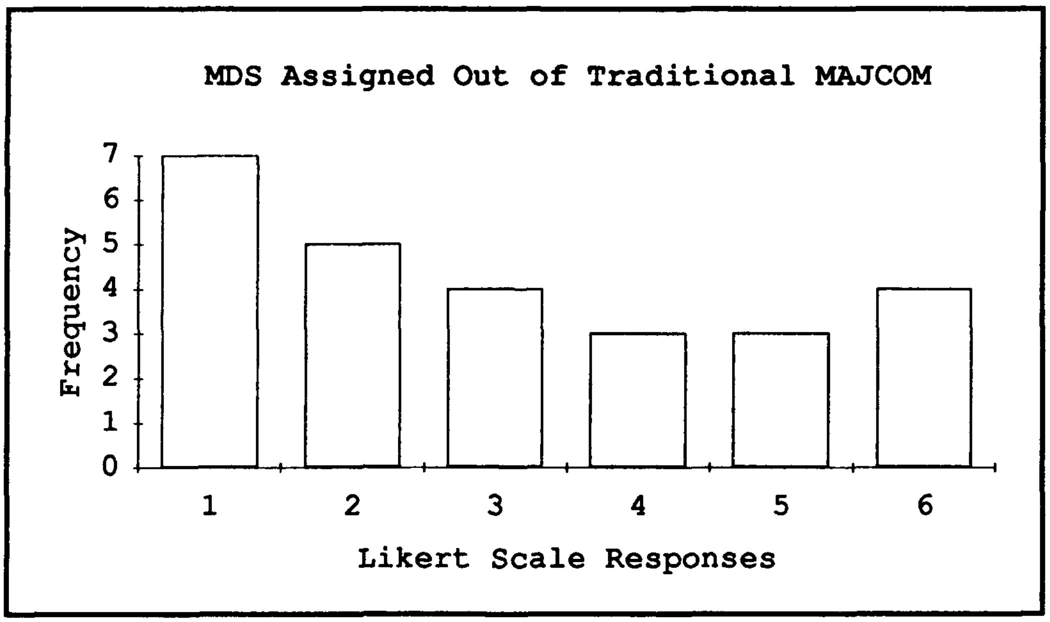

Maintenance Fix Rates
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

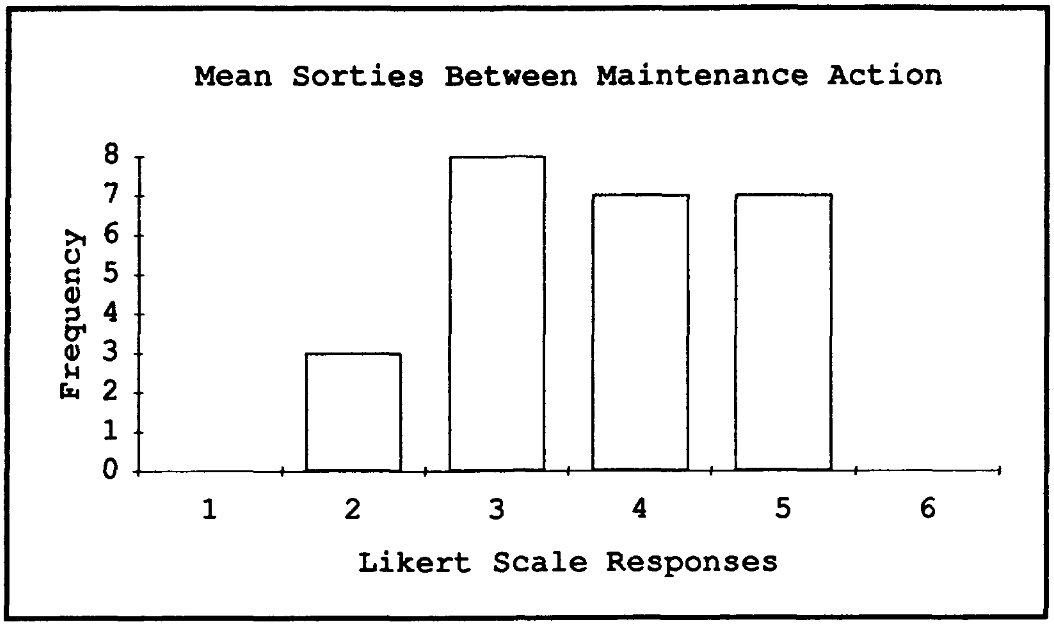

Maintenance Manhours per Sortie
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

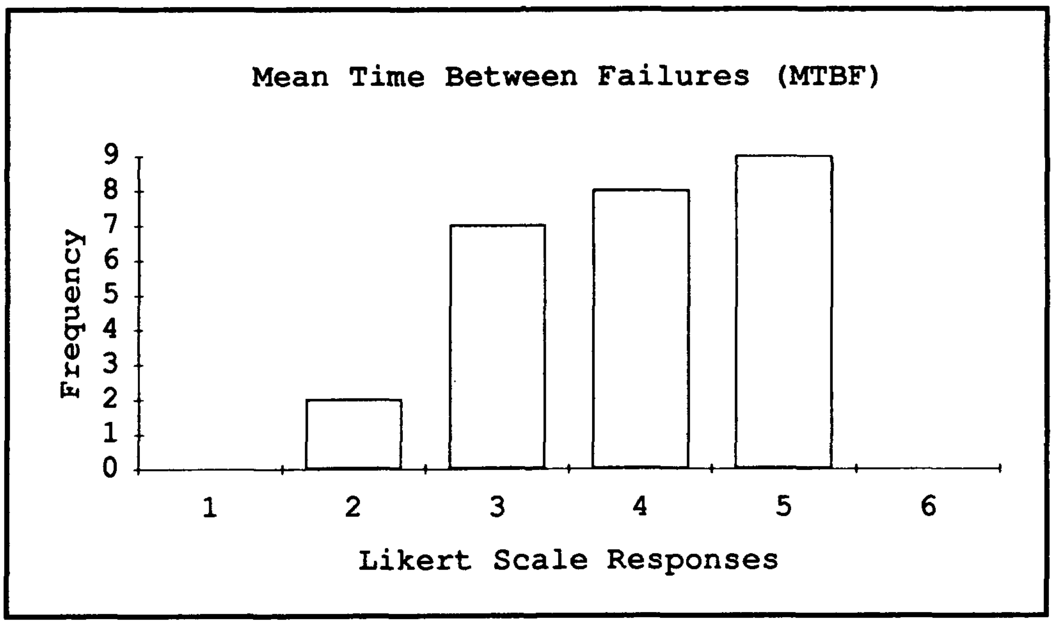

Maintenance Policies
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

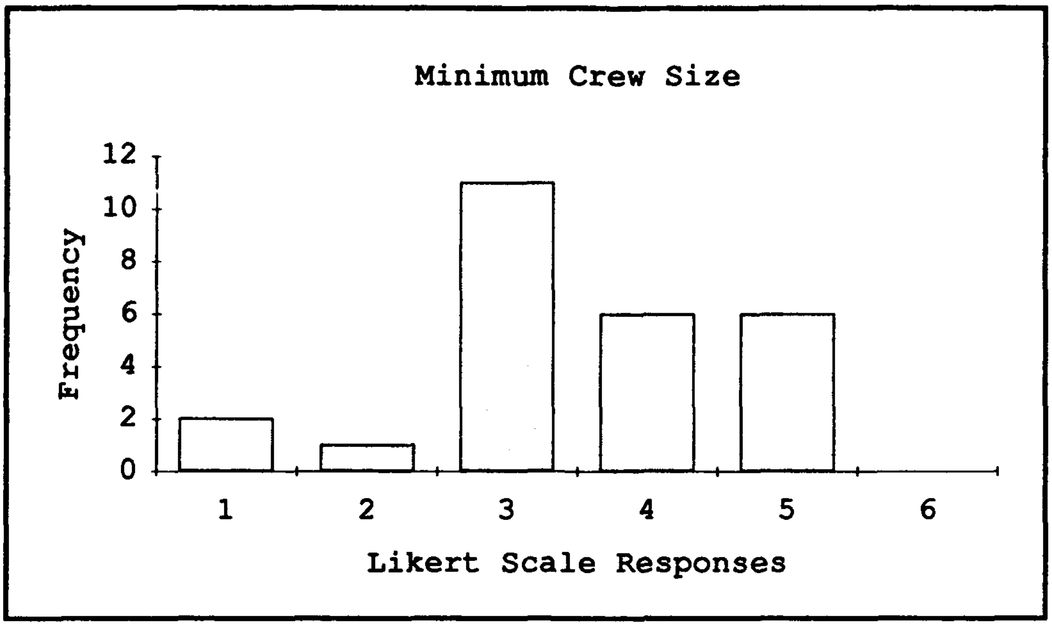

Manhour Availability Factors
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

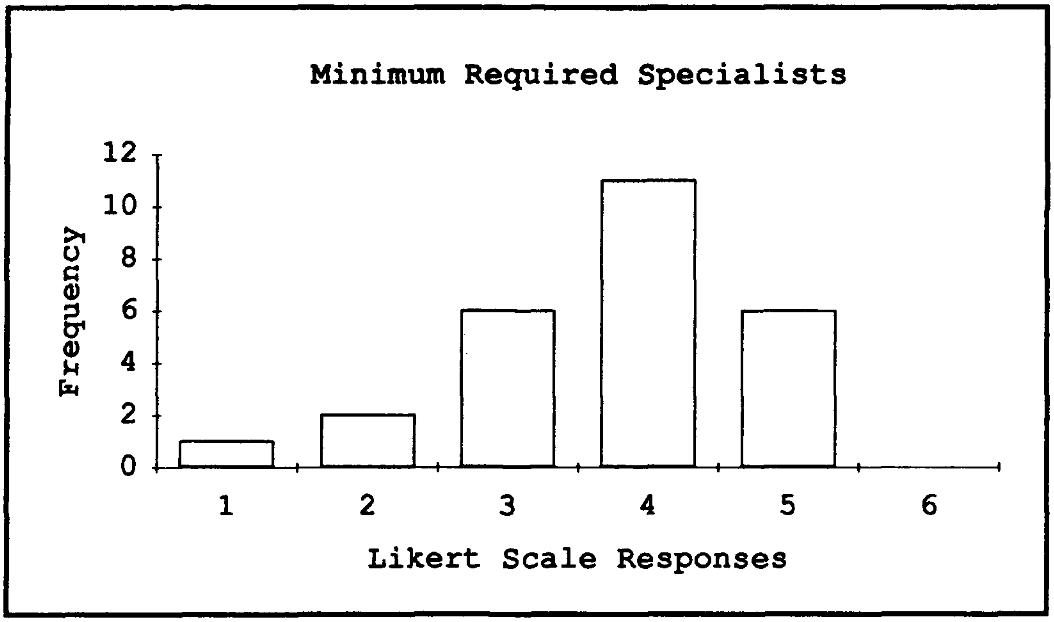

Manpower Standards
Frequency
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

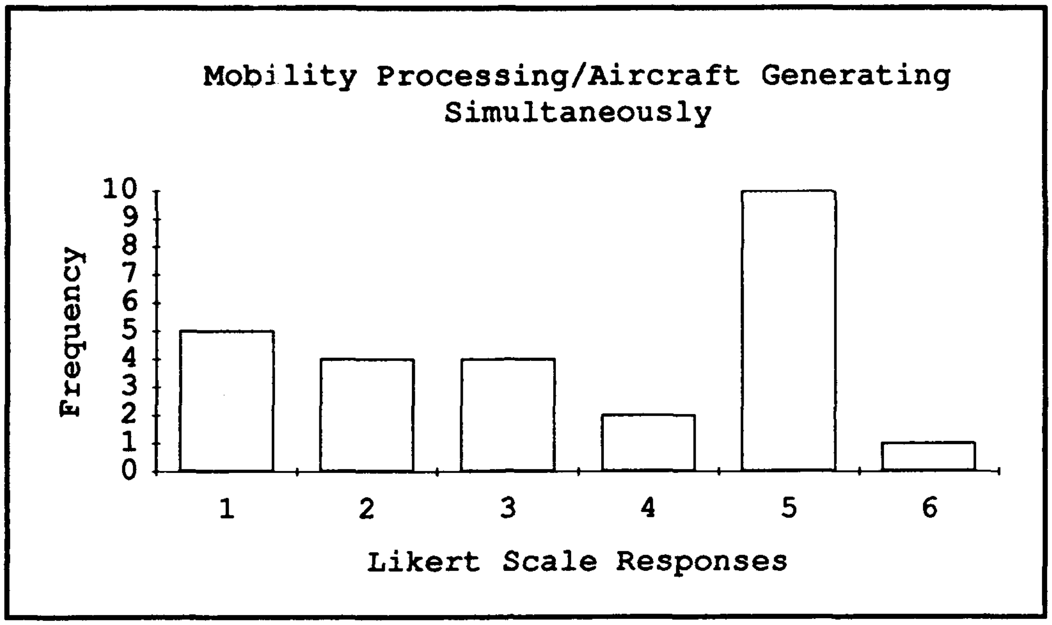

MDS Assigned Out of Traditional MAJCOM
Frequency
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

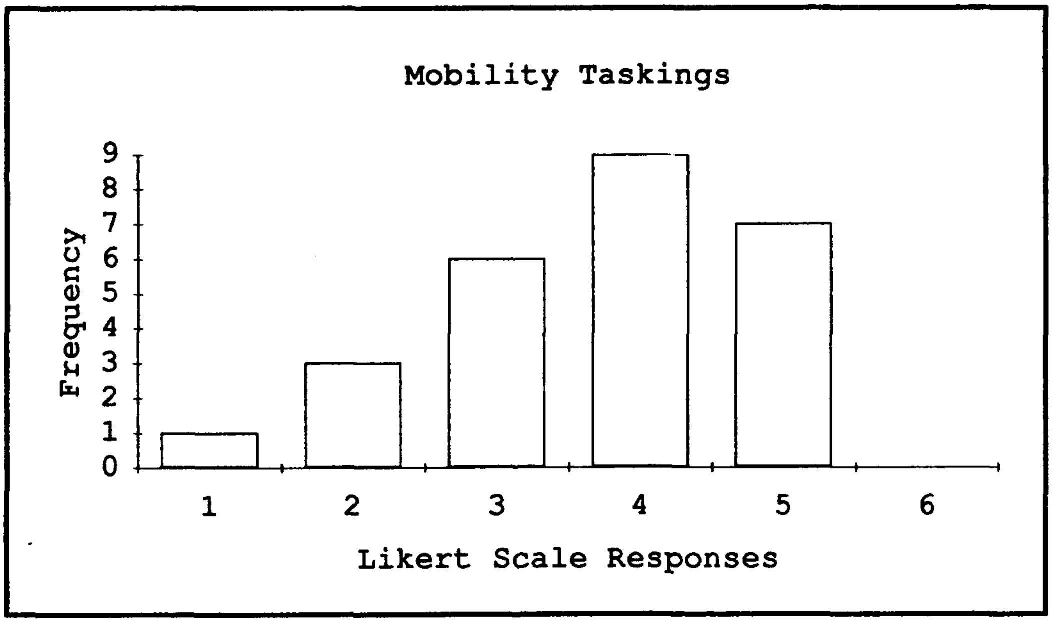

Mean Sorties Between Maintenance Action
Frequency
0
1
2
3
4
5
6
7
8
1
2
3
4
5
6
Likert Scale Responses

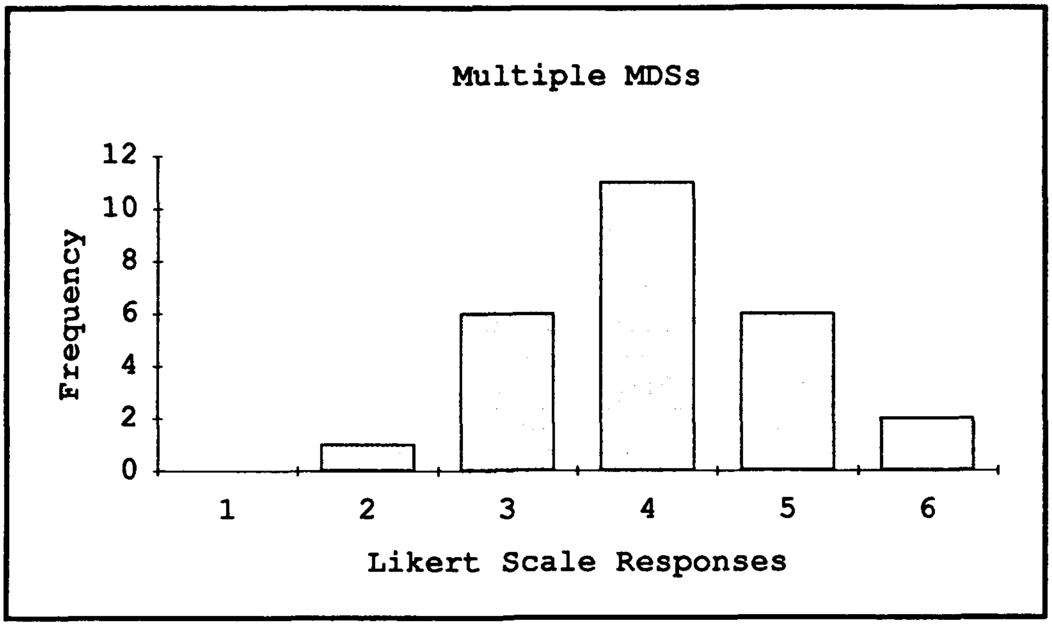

Mean Time Between Failures (MTBF)
Frequency
0
1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
Likert Scale Responses

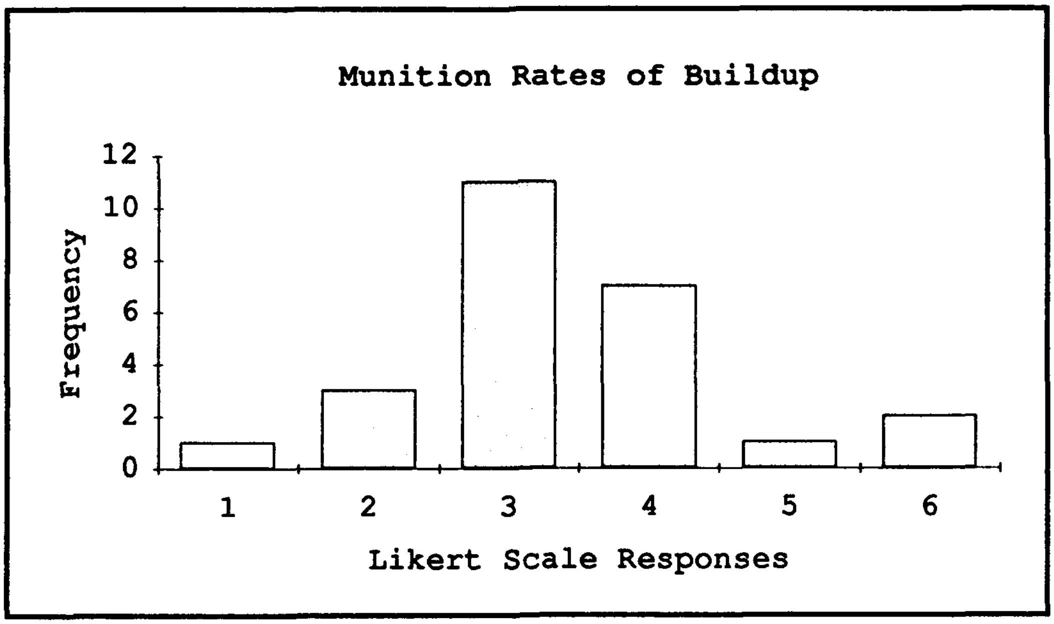

Minimum Crew Size
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
Likert Scale Responses

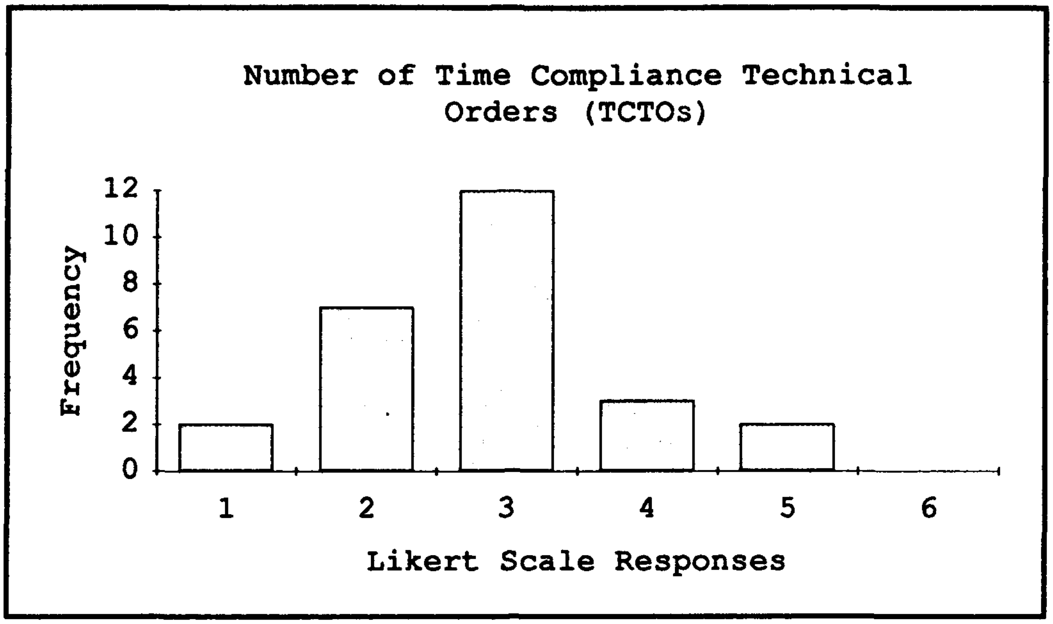

Minimum Required Specialists
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
Likert Scale Responses

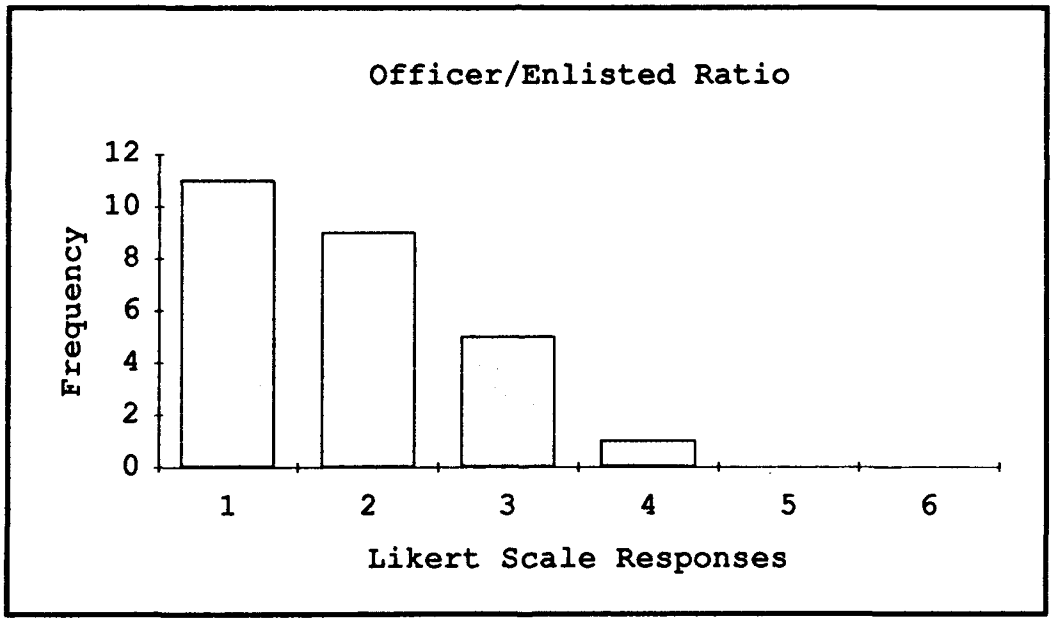

Mobility Processing/Aircraft Generating Simultaneously
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

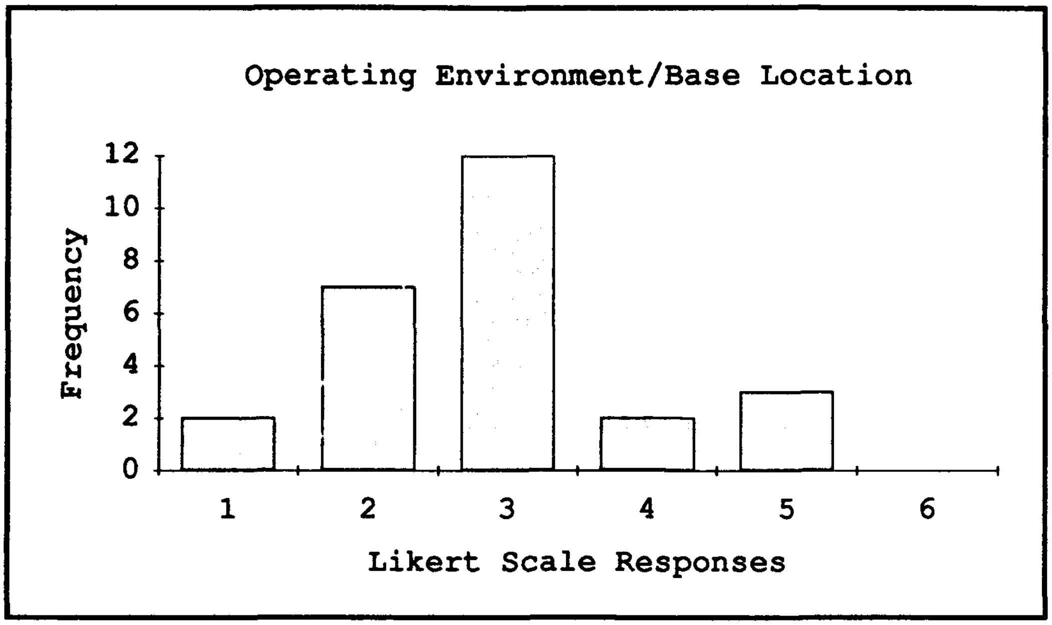

Mobility Taskings
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

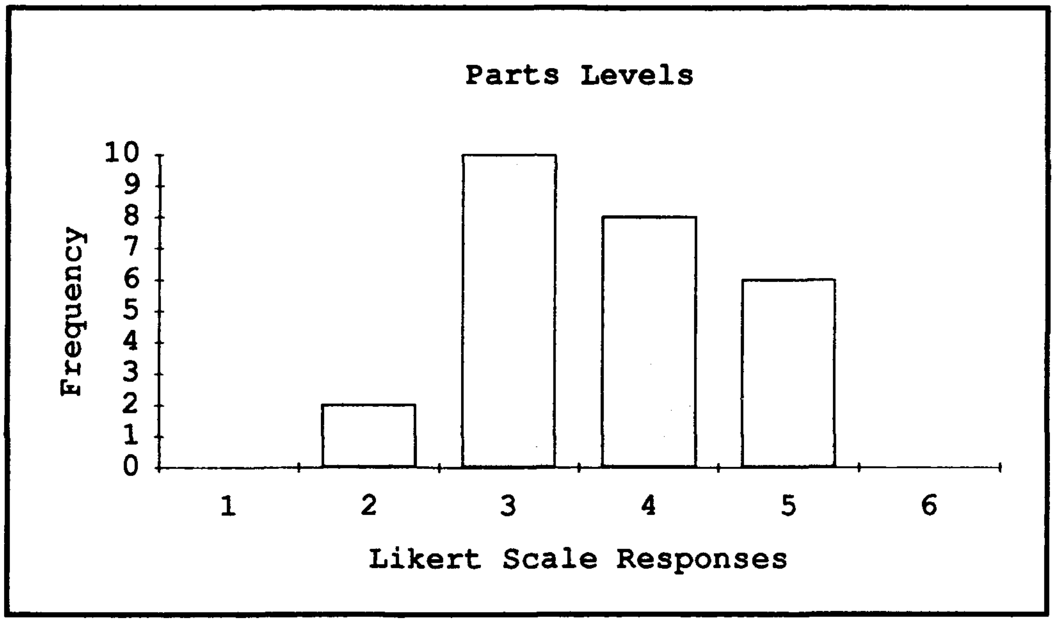

Multiple MDSs
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

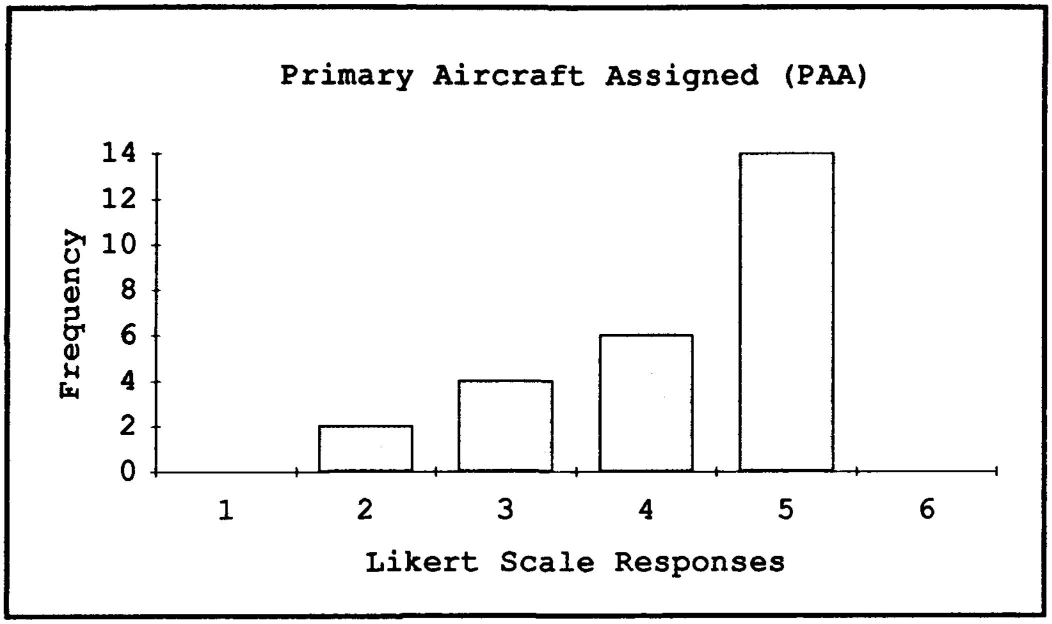

Munition Rates of Buildup
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses


Number of Time Compliance Technical Orders (TCTOs)
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

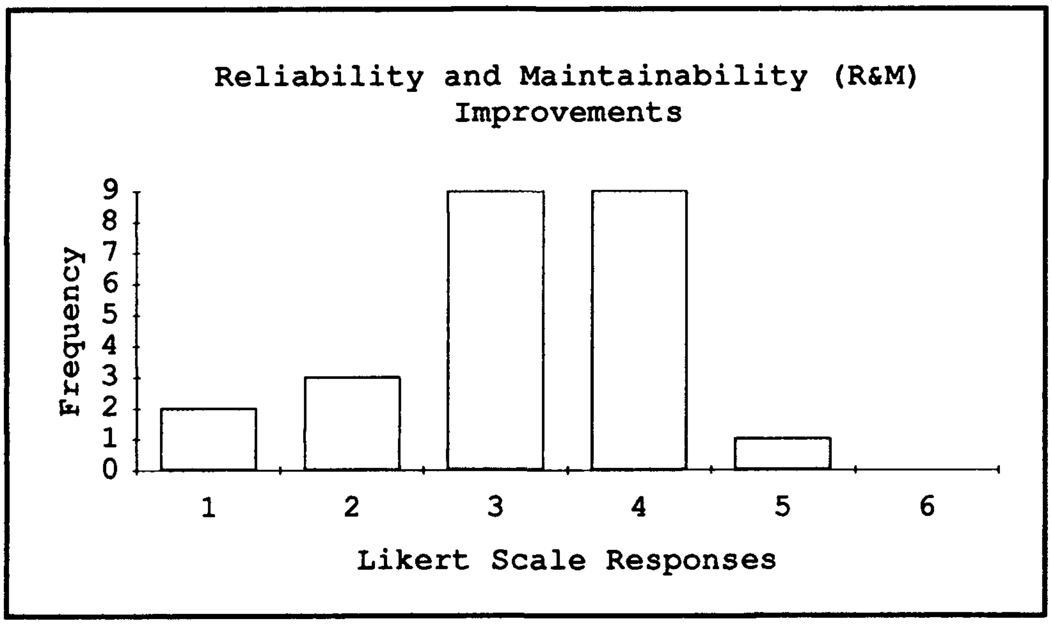

Officer/Enlisted Ratio
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses


Operating Environment/Base Location
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

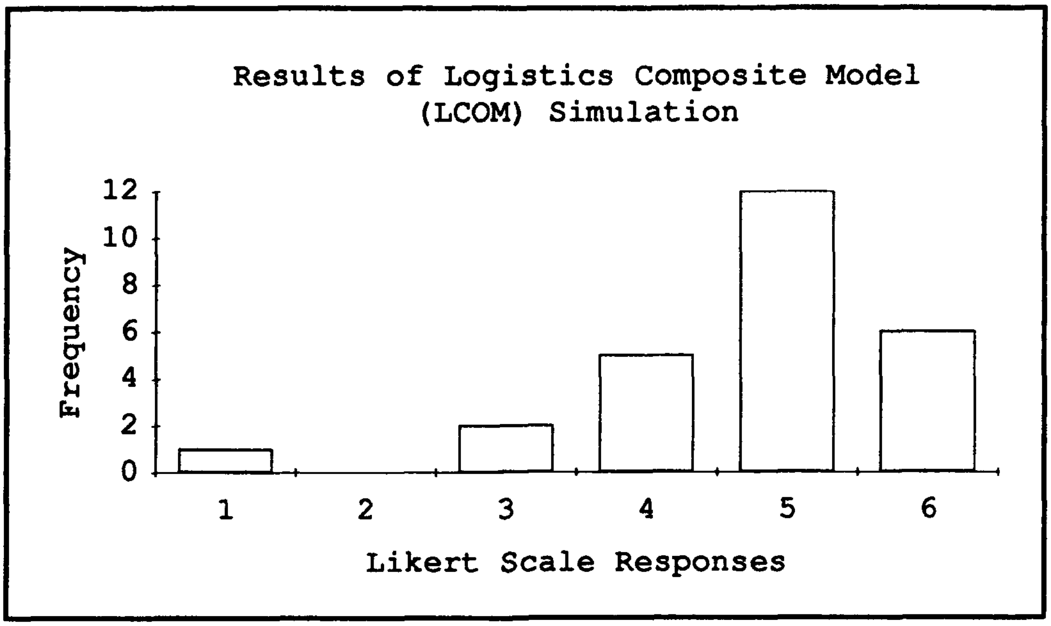

Parts Levels
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

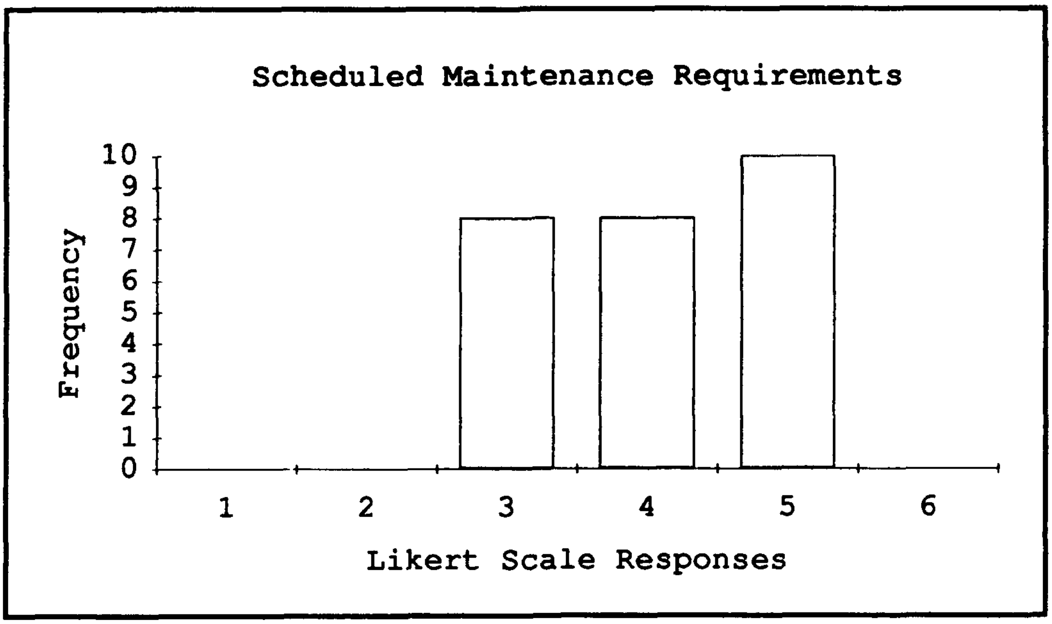


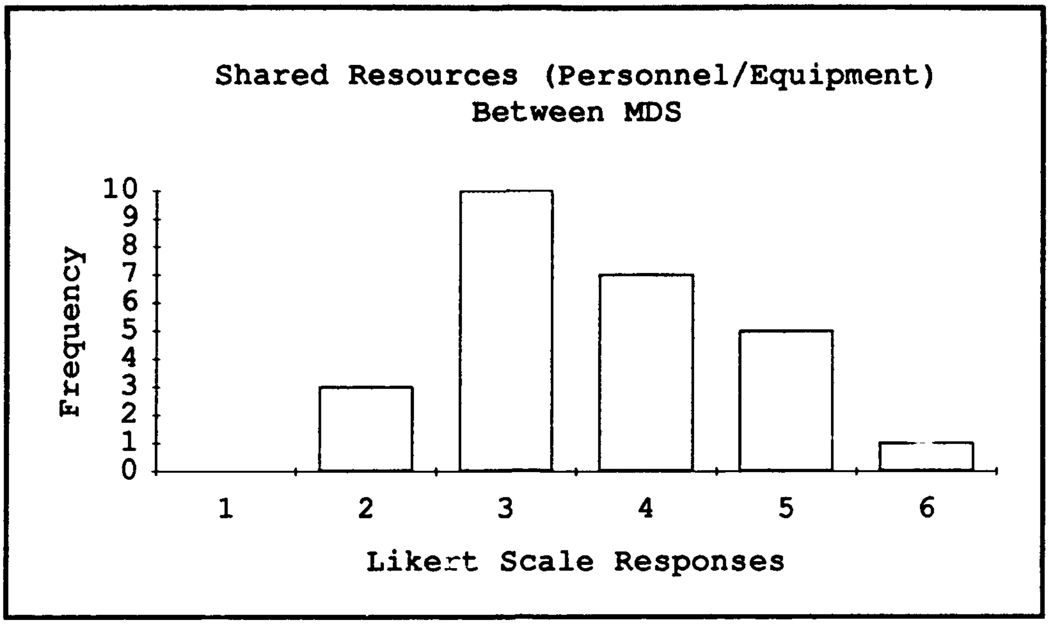
Primary Aircraft Assigned (PAA)
Frequency
14
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

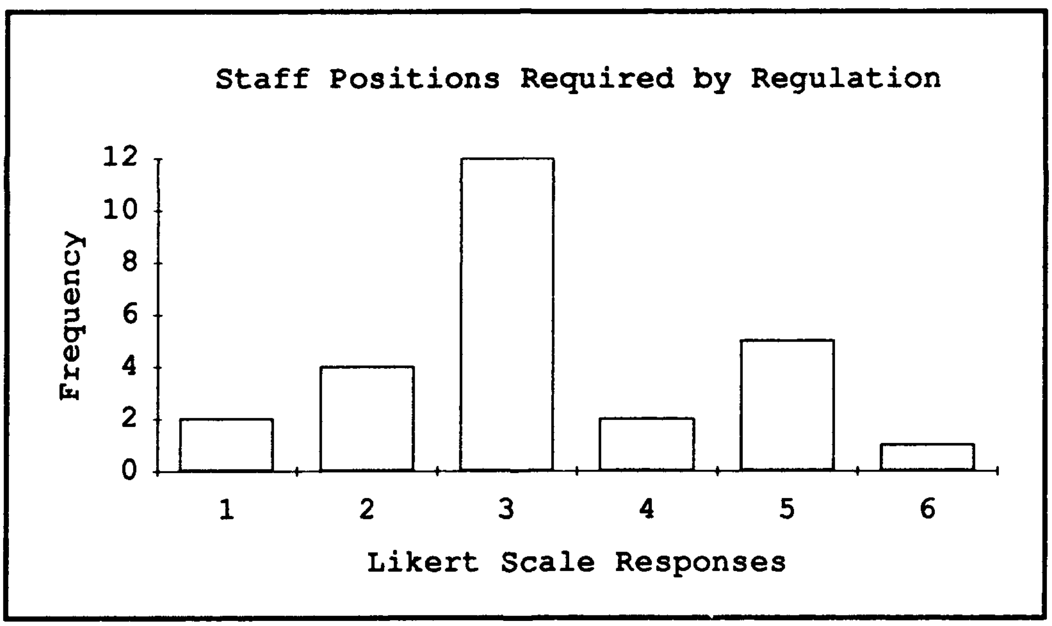


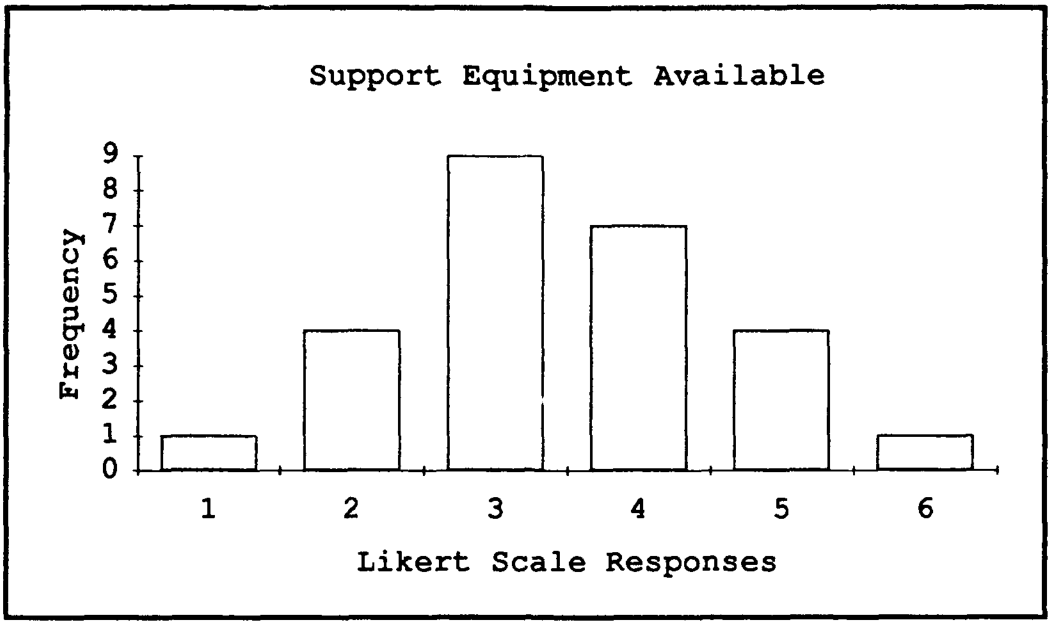
Reliability and Maintainability (R&M) Improvements
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses


Results of Logistics Composite Model
(LCOM) Simulation
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

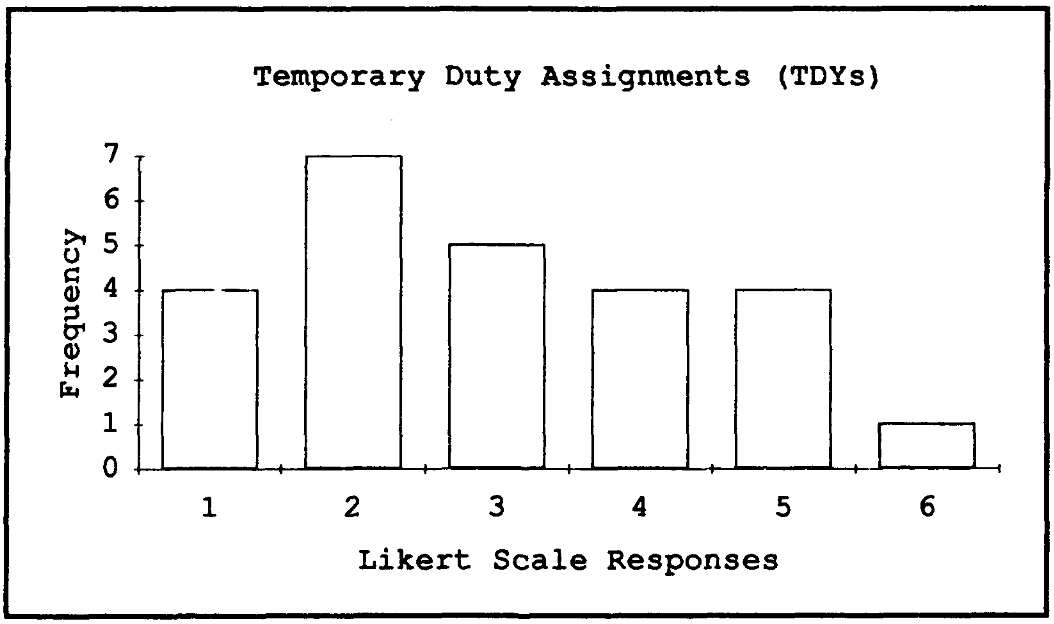

Scheduled Maintenance Requirements
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses


Shared Resources (Personnel/Equipment)
Between MDS
Frequency
0
1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
Likert Scale Responses

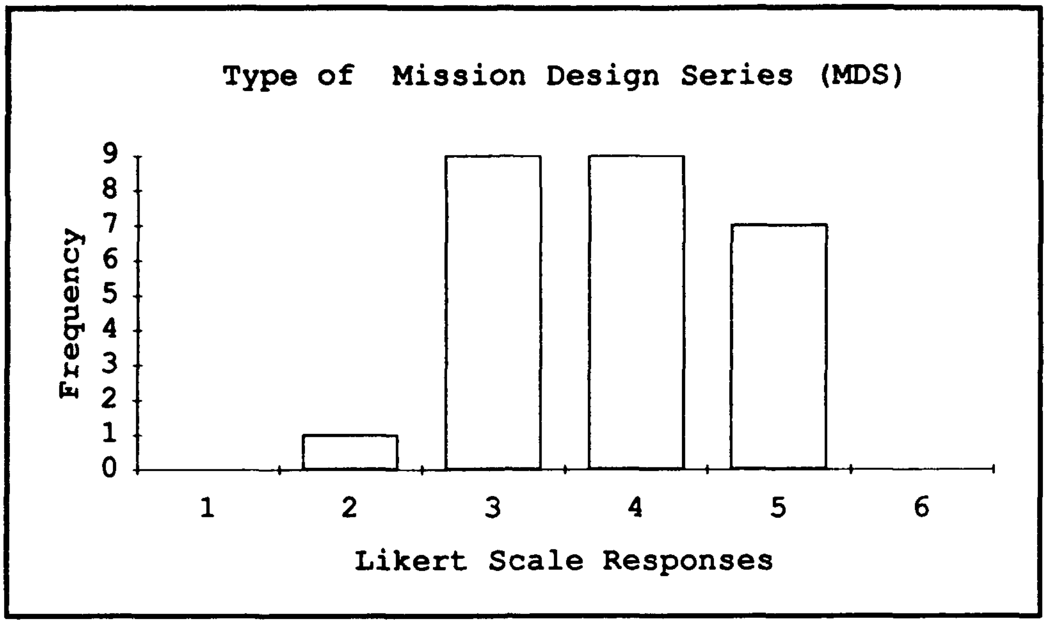

Staff Positions Required by Regulation
Frequency
0
2
4
6
8
10
12
1
2
3
4
5
6
Likert Scale Responses

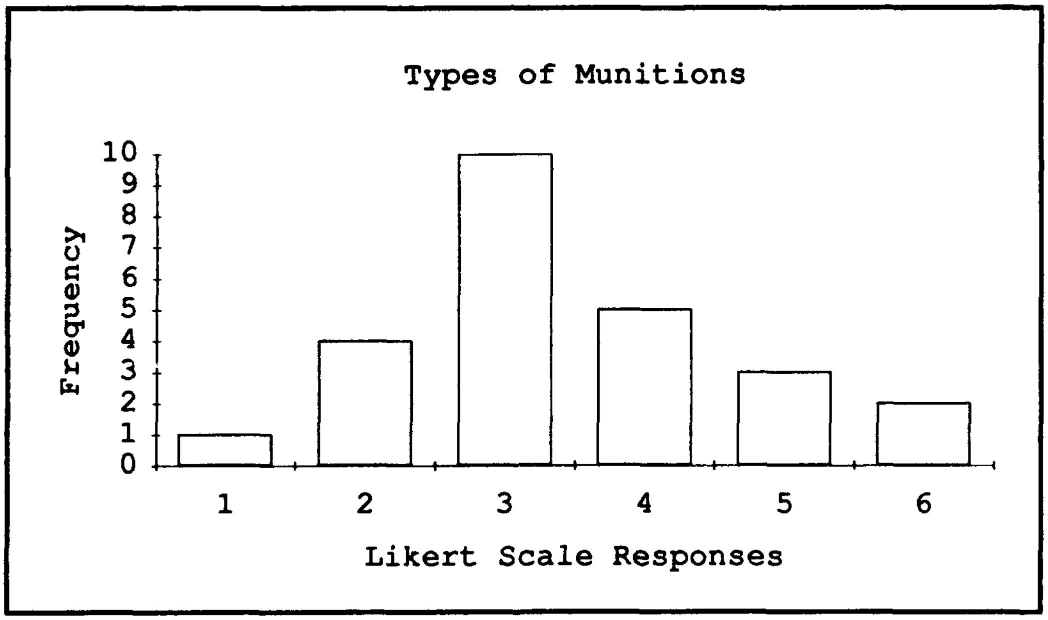


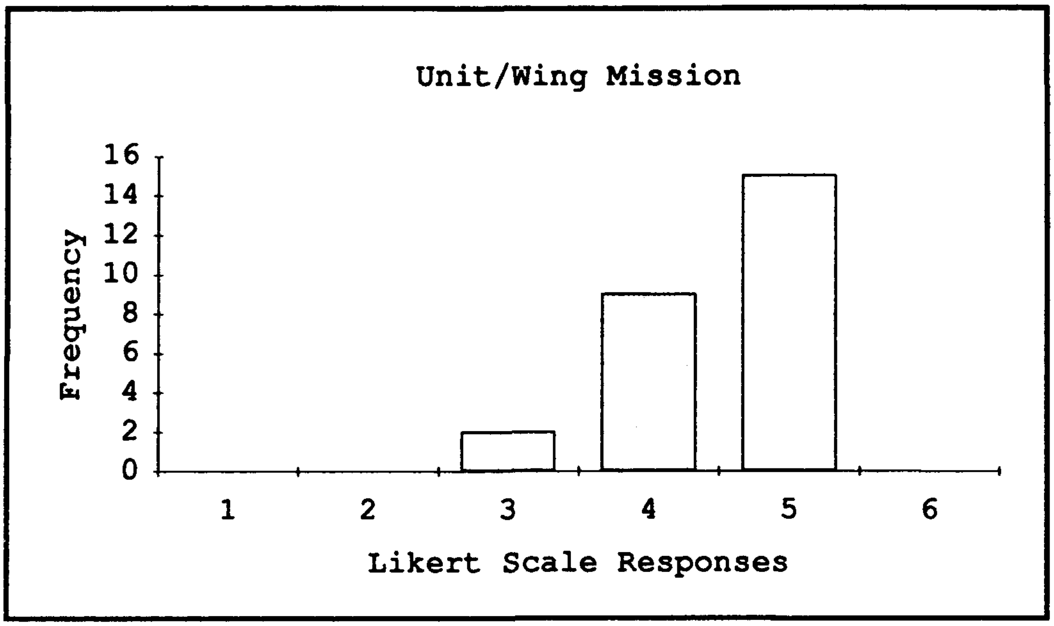
Support Equipment Available
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

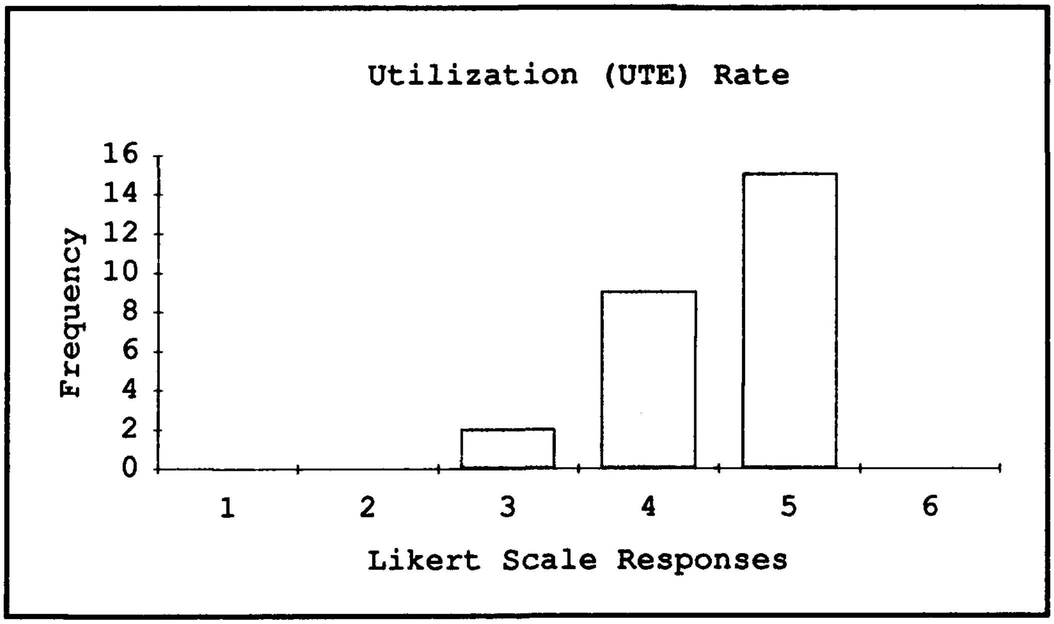


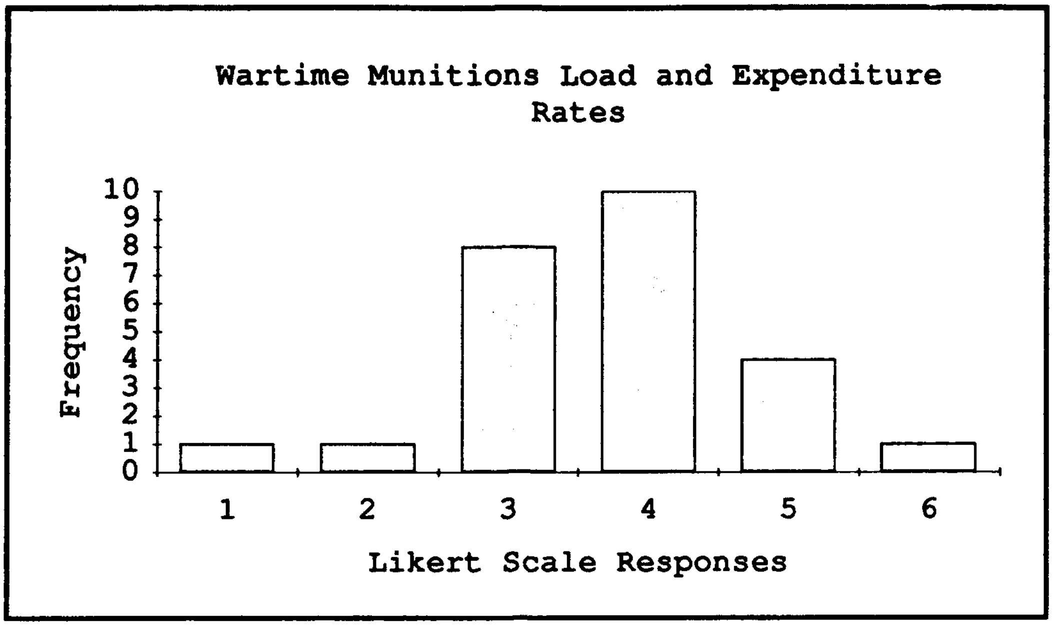
Temporary Duty Assignments (TDYs)
Frequency
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

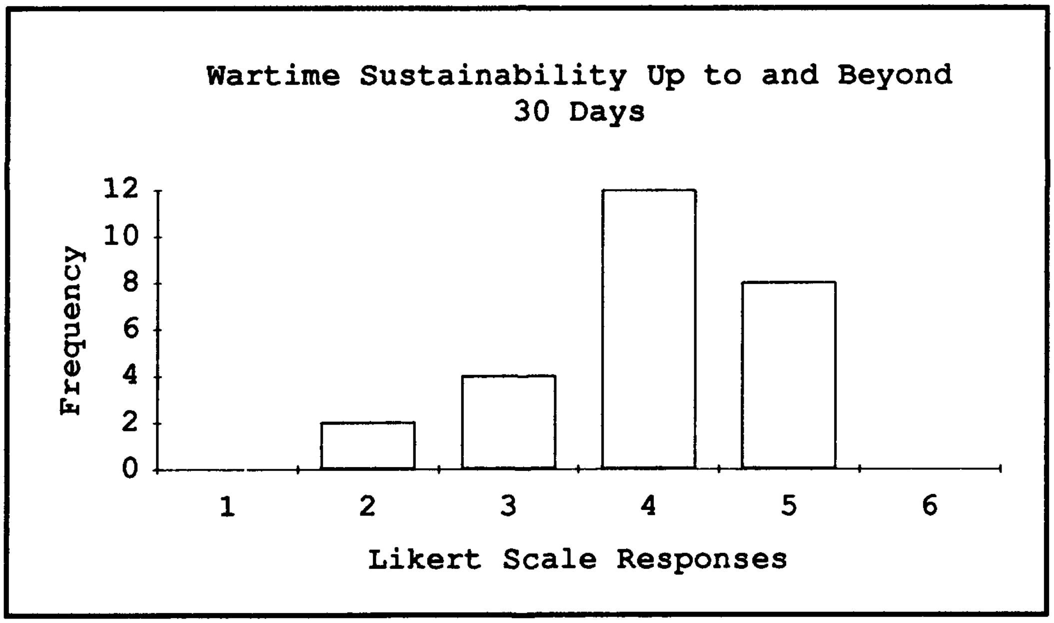

Type of Mission Design Series (MDS)
Frequency
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

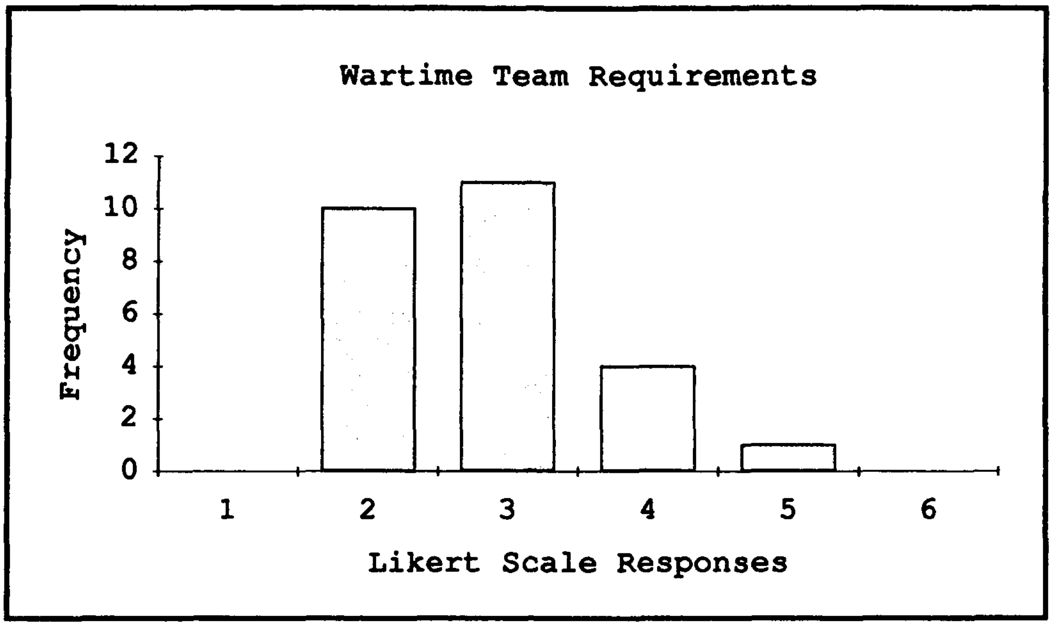

Types of Munitions
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses

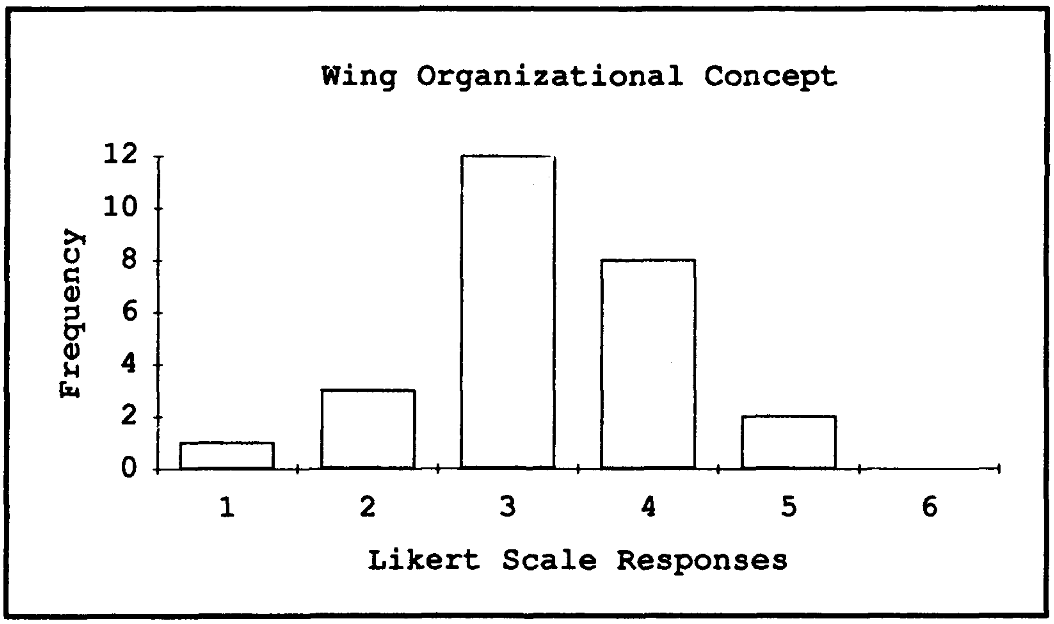

Unit/Wing Mission
16
14
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
Likert Scale Responses


Utilization (UTE) Rate
16
14
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
Likert Scale Responses


Wartime Munitions Load and Expenditure Rates
Frequency
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
Likert Scale Responses


Wartime Sustainability Up to and Beyond 30 Days
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses


Wartime Team Requirements
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses


Wing Organizational Concept
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

Appendix F: Wilk-Shapiro Test Statistics

Factor	Maintenance	Manpower
	Wilk-Shapiro Test Statistic	
Accuracy of Core Automated Maintenance (CAMS) Data	.9604	.8042
Additional Aircraft Systems	.8422	.8929
AFSC/Grade/Skill Level Requirements	.8507	.9319
Age of Fleet	.8507	.8768
Aircraft Maintainability	.8472	.8932
Aircraft Turn Time	.8858	.8985
Aircrew Ratio	.9092	.8954
Availability of Fuel Tank Buildup Augmentees	.9604	.8042
Average Sortie Duration (ASD)	.8972	.7922
Backup Aircraft Inventory (BAI)	.8317	.7922
Deployment Concepts	.7875	.7503
Effects of Multiple MDSs on Backshop Training	.7885	.8234
Funded Flying Hours	.8876	.8526
Geographically Separated Unit	.9584	.8962
Maintenance Concept	.9125	.8241
Maintenance Facilities Layout	.7350	.8929
Maintenance Fix Rates	.7034	.8731
Maintenance Manhours per Sortie	.8786	.8311
Maintenance Policies	.7195	.9096
Manhour Availability Factors	.8143	.8808
Manpower Standards	.8853	.8955
MDS Assigned Out of Traditional MAJCOM	.9414	.7691
Mean Sorties Between Maintenance Action	.8409	.8123
Mean Time Between Failures (MTBF)	.8192	.6657
Minimum Crew Size	.6663	.8465
Minimum Required Specialists	.8786	.8836
Mobility Processing/Aircraft Generating Simultaneously	.4591	.7801
Mobility Taskings	.7732	.9321
Multiple MDSs	.8317	.8820
Munitions Rates of Buildup	.9221	.7946
Number of TCTOs	.7467	.8199
Officer/Enlisted Ratio	.8317	.6657
Operating Env/Base Location	.8292	.8547
Parts Levels	.7971	.9034
Primary Aircraft Assigned (PAA)	.7971	.7577

Factor	Maintenance	Manpower
	Wilk-Shapiro Test Statistic	
Reliability & Maintainability Improvements	.8153	.8346
Results of LCOM Simulation	.8133	.5228
Scheduled Maintenance Requirements	.8428	.8162
Shared Resources Between MDSs	.8862	.8855
Staff Positions Required by Regulation	.7703	.8509
Support Equipment Available	.9073	.8305
Temporary Duty Assignments (TDYs)	.9042	.8223
Type of Mission Design Series (MDS)	.8507	.8877
Types of Munitions	.7510	.9191
Unit/Wing Mission	.7971	.6410
Utilization (UTE) Rate	.5810	.7742
Wartime Munitions Load and Expenditure Rates	.8959	.8486
Wartime Sustainability Up to and Beyond 30 Days	.9073	.7742
Wartime Team Requirements	.7350	.5940
Wing Organizational Concept	.8709	.8968

Appendix G: Mann-Whitney U Tables

Accuracy of CAMS Data Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	250.0	14	145.0	17.9
Maintenance	101.0	12	23.0	8.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.0019

Additional Aircraft Systems Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	190.5	14	85.5	13.6
Maintenance	160.5	12	82.5	13.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.9590

AFSC/Grade/Skill Level Requirements Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	132.0	14	27.0	9.4
Maintenance	219.0	12	141.0	18.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.0037

Age of Fleet Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	145.5	14	40.5	10.4
Maintenance	205.5	12	127.5	17.1
Total	351.0	26		
Two-tailed p-value for normal approximation				.0270

Aircraft Maintainability Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	178.5	14	73.5	12.8
Maintenance	172.5	12	94.5	14.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.6070

Aircraft Turn Time Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	175.5	14	70.5	12.5
Maintenance	175.5	12	97.5	14.6
Total	351.0	26		
Two-tailed p-value for normal approximation				.5037

Aircrew Ratio Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	173.0	14	68.0	12.4
Maintenance	178.0	12	100.0	14.8
Total	351.0	26		
Two-tailed p-value for normal approximation				.4253

Availability of Fuel Tank Buildup Augmentees Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	148.0	14	43.0	10.6
Maintenance	203.0	12	125.0	16.9
Total	351.0	26		
Two-tailed p-value for normal approximation				.0372

Average Sortie Duration (ASD) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	240.0	14	135.0	17.1
Maintenance	111.0	12	33.0	9.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.0094

Backup Aircraft Inventory (BAI) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	109.5	14	4.5	7.8
Maintenance	241.5	12	163.5	20.1
Total	351.0	26		
Two-tailed p-value for normal approximation				.0000

Deployment Concepts Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	198.0	14	93.0	14.1
Maintenance	153.0	12	75.0	12.8
Total	351.0	26		
Two-tailed p-value for normal approximation				.6620

Effects of Multiple MDS on Backshop Training Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	138.5	14	33.5	9.9
Maintenance	212.5	12	134.5	17.7
Total	351.0	26		
Two-tailed p-value for normal approximation				.0101

Funded Flying Hours Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	178.0	14	73.0	12.7
Maintenance	173.0	12	95.0	14.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.5892

Geographically Separated Unit (GSU) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	180.5	14	75.5	12.9
Maintenance	170.5	12	92.5	14.2
Total	351.0	26		
Two-tailed p-value for normal approximation				.6807

Maintenance Concept Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	203.0	14	98.0	14.5
Maintenance	148.0	12	70.0	12.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.4875

Maintenance Facilities Layout Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	128.0	14	23.0	9.1
Maintenance	223.0	12	145.0	18.6
Total	351.0	26		
Two-tailed p-value for normal approximation				.0019

Maintenance Fix Rates Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	159.0	14	54.0	11.4
Maintenance	192.0	12	114.0	16.0
Total	351.0	26		
Two-tailed p-value for normal approximation				.1292

Maintenance Manhours per Sortie Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	125.5	14	20.5	9.0
Maintenance	225.5	12	147.5	18.8
Total	351.0	26		
Two-tailed p-value for normal approximation				.0012

Maintenance Policies Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	198.5	14	93.5	14.2
Maintenance	152.5	12	74.5	12.7
Total	351.0	26		
Two-tailed p-value for normal approximation				.6434

Manhour Availability Factors Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	181.5	14	76.5	13.0
Maintenance	169.5	12	91.5	14.1
Total	351.0	26		
Two-tailed p-value for normal approximation				.7188

Manpower Standards Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	191.0	14	86.0	13.6
Maintenance	160.0	12	82.0	13.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.9385

MDS Assigned Out of Traditional MAJCOM Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	146.5	14	41.5	10.5
Maintenance	204.5	12	126.5	17.0
Total	351.0	26		
Two-tailed p-value for normal approximation				.0308

Mean Sorties Between Maintenance Action Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	223.5	14	118.5	16.0
Maintenance	101.5	11	35.5	9.2
Total	325.0	25		
Two-tailed p-value for normal approximation				.0248

Mean Time Between Failures (MTBF) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	245.0	14	140.0	17.5
Maintenance	106.0	12	28.0	8.8
Total	351.0	26		
Two-tailed p-value for normal approximation				.0043

Minimum Crew Size Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	243.5	14	138.5	17.4
Maintenance	107.5	12	29.5	9.0
Total	351.0	26		
Two-tailed p-value for normal approximation				.0055

Minimum Required Specialists Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	192.0	14	87.0	13.7
Maintenance	159.0	12	81.0	13.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.8977

Mobility Processing/Aircraft Generating Simultaneously Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	117.0	14	12.0	8.4
Maintenance	234.0	12	156.0	19.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.0002

Mobility Taskings Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	130.5	14	25.5	9.3
Maintenance	220.5	12	142.5	18.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.0029

Multiple MDSs Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	178.0	14	73.0	12.7
Maintenance	173.0	12	95.0	14.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.5892

Munitions Rates of Buildup Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	187.5	14	82.5	13.4
Maintenance	137.5	11	71.5	12.5
Total	325.0	25		
Two-tailed p-value for normal approximation				.7843

Number of TCTOs Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	122.5	14	17.5	8.8
Maintenance	228.5	12	150.5	19.0
Total	351.0	26		
Two-tailed p-value for normal approximation				.0007

Officer/Enlisted Ratio Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	154.0	14	49.0	11.0
Maintenance	197.0	12	119.0	16.4
Total	351.0	26		
Two-tailed p-value for normal approximation				.0760

Operating Environment/Base Location Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	184.0	14	79.0	13.1
Maintenance	167.0	12	89.0	13.9
Total	351.0	26		
Two-tailed p-value for normal approximation				.8170

Parts Levels Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	193.0	14	88.0	13.8
Maintenance	158.0	12	80.0	13.2
Total	351.0	26		
Two-tailed p-value for normal approximation				.8571

Primary Aircraft Assigned (PAA) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	187.0	14	82.0	13.4
Maintenance	164.0	12	86.0	13.7
Total	351.0	26		
Two-tailed p-value for normal approximation				.9385

Reliability and Maintainability (R&M) Improvements Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	194.0	14	89.0	13.9
Maintenance	106.0	10	51.0	10.6
Total	300.0	24		
Two-tailed p-value for normal approximation				.2787

Results of LCOM Simulation Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	177.5	14	72.5	12.7
Maintenance	173.5	12	95.5	14.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.5715

Scheduled Maintenance Requirements Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	197.0	14	92.0	14.1
Maintenance	154.0	12	96.0	12.8
Total	351.0	26		
Two-tailed p-value for normal approximation				.6997

Shared Resources Between MDSs Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	172.0	14	67.0	12.3
Maintenance	179.0	12	101.0	14.9
Total	351.0	26		
Two-tailed p-value for normal approximation				.3961

Staff Positions Required by Regulation Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	145.0	14	40.0	10.4
Maintenance	206.0	12	128.0	17.2
Total	351.0	26		
Two-tailed p-value for normal approximation				.0253

Support Equipment Available Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	177.0	14	72.0	12.6
Maintenance	174.0	12	96.0	14.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.5542

Temporary Duty Assignments (TDYs) Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	94.0	13	3.0	7.2
Maintenance	231.0	12	153.0	19.3
Total	325.0	25		
Two-tailed p-value for normal approximation				.0001

Type of MDS Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	183.0	14	78.0	13.1
Maintenance	168.0	12	90.0	14.0
Total	351.0	26		
Two-tailed p-value for normal approximation				.7773

Types of Munitions Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	190.0	14	85.0	13.6
Maintenance	135.0	11	69.0	12.3
Total	325.0	25		
Two-tailed p-value for normal approximation				.6814

Unit/Wing Mission Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	206.0	14	101.0	14.7
Maintenance	145.0	12	67.0	12.1
Total	351.0	26		
Two-tailed p-value for normal approximation				.3961

Utilization (UTE) Rate Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	164.5	14	59.5	11.8
Maintenance	186.5	12	108.5	15.5
Total	351.0	26		
Two-tailed p-value for normal approximation				.2170

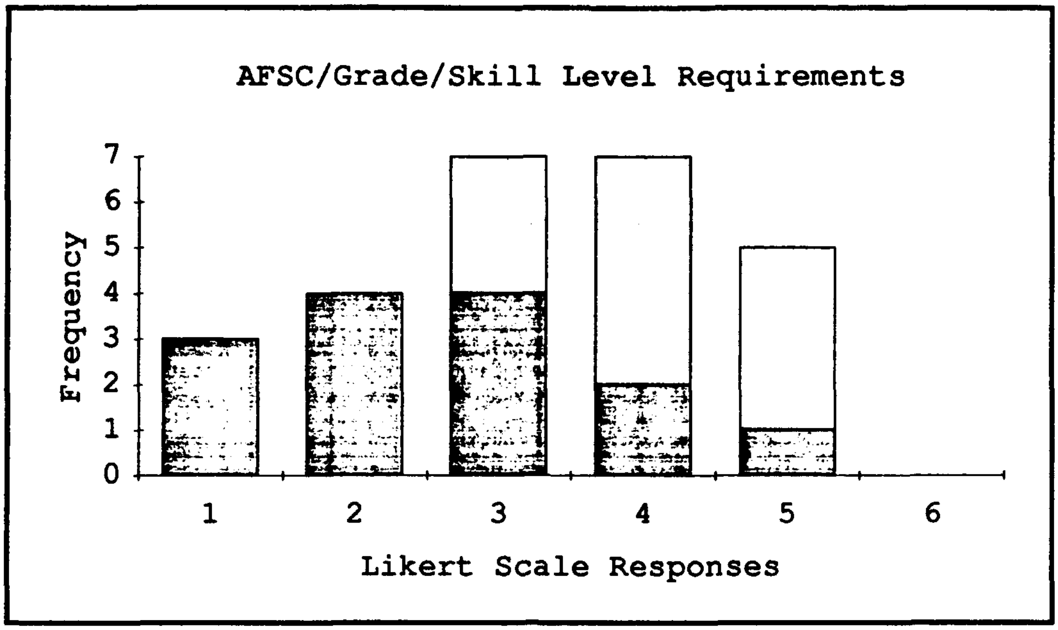
Wartime Munitions Load and Expenditure Rates Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	209.0	14	104.0	14.9
Maintenance	116.0	11	50.0	10.5
Total	325.0	25		
Two-tailed p-value for normal approximation				.1469

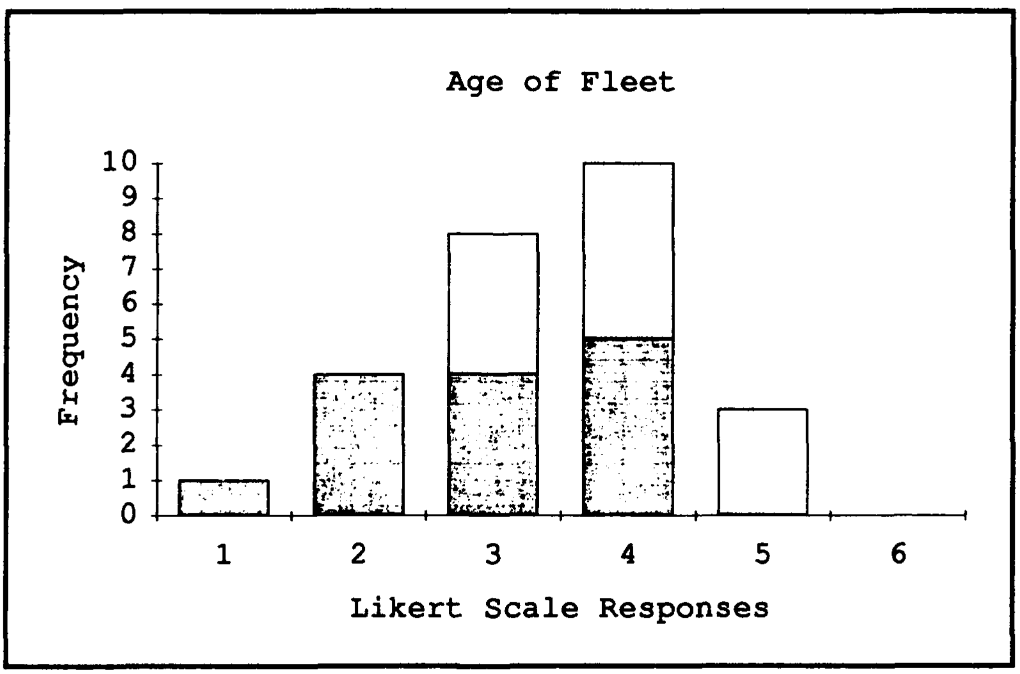
Wartime Sustainability up to and Beyond 30 Days Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	227.0	14	122.0	16.2
Maintenance	124.0	12	46.0	10.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.0538

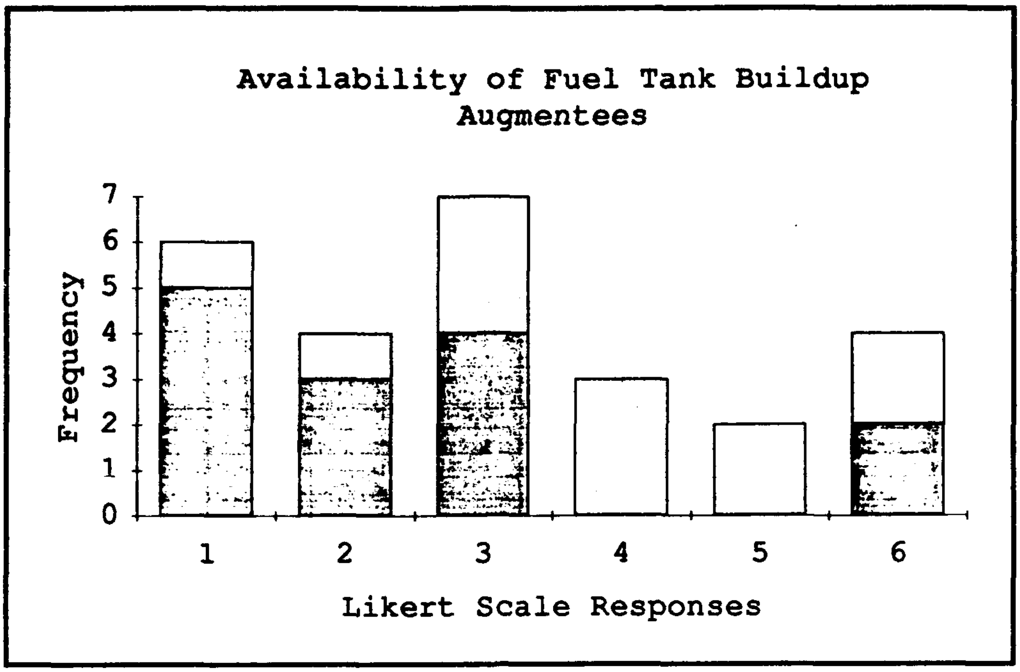
Wartime Team Requirements Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	119.0	14	14.0	8.5
Maintenance	232.0	12	154.0	19.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.0004

Wing Organizational Concept Maintenance vs Manpower				
Variable	Rank Sum	Sample Size	U Stat	Mean Rank
Manpower	167.5	14	62.5	12.0
Maintenance	183.5	12	105.5	15.3
Total	351.0	26		
Two-tailed p-value for normal approximation				.2801

Appendix H: Stacked Histograms for Differences in Opinion






Availability of Fuel Tank Buildup Augmentees
Frequency
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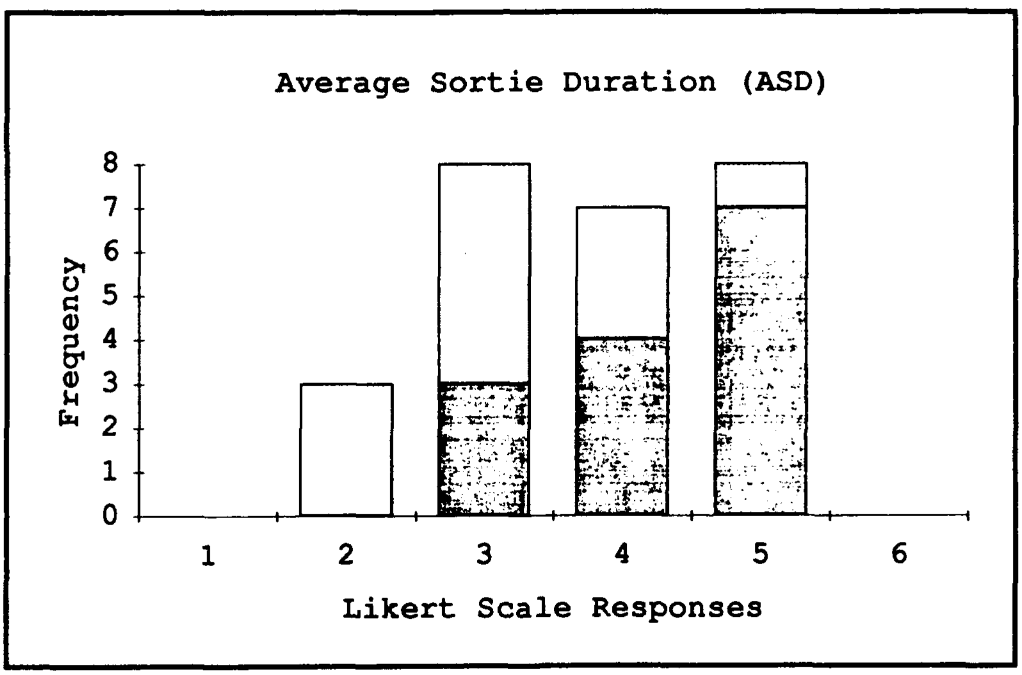
2
3
4
5
6
7
1
2
3
4
5
6
Likert Scale Responses


Average Sortie Duration (ASD)
Frequency
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2
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4
5
6
7
8
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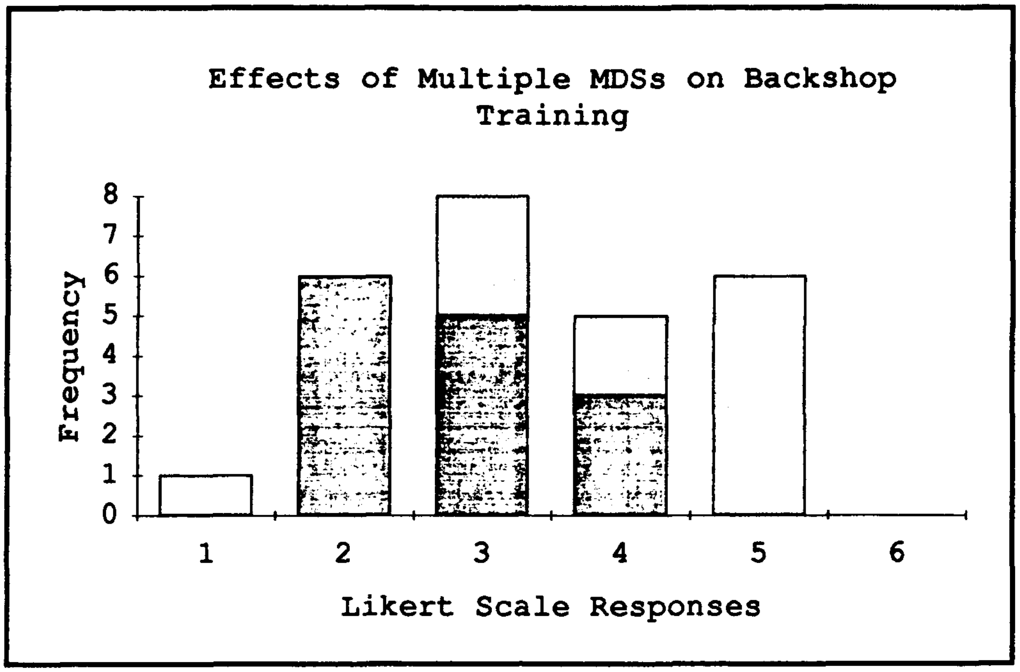
2
3
4
5
6
Likert Scale Responses


Effects of Multiple MDSs on Backshop Training
Frequency
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7
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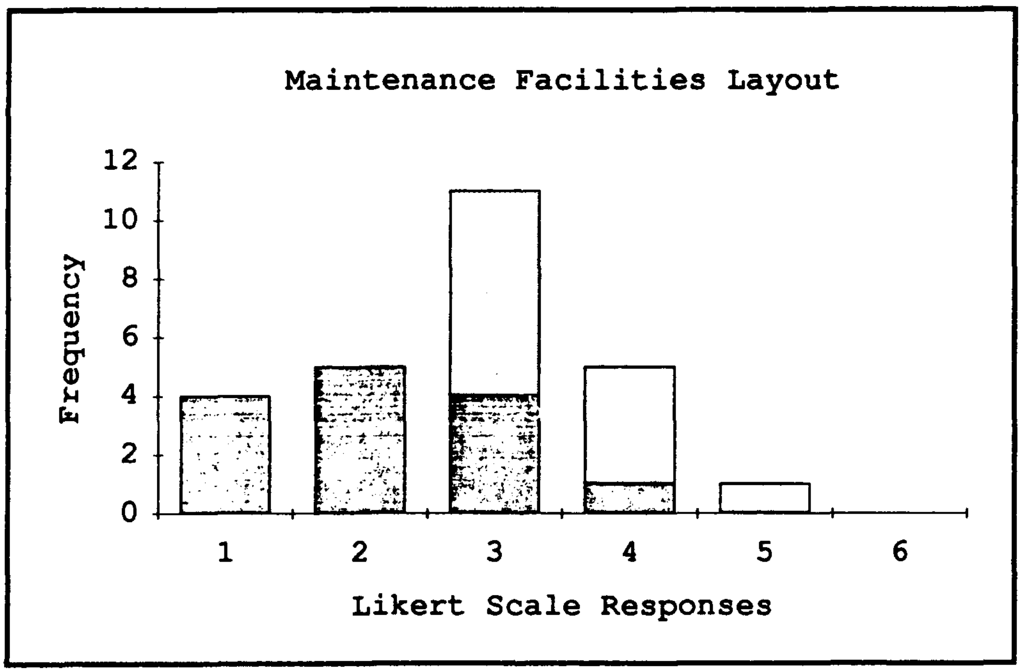
1
2
3
4
5
6
Likert Scale Responses


Maintenance Facilities Layout
Frequency
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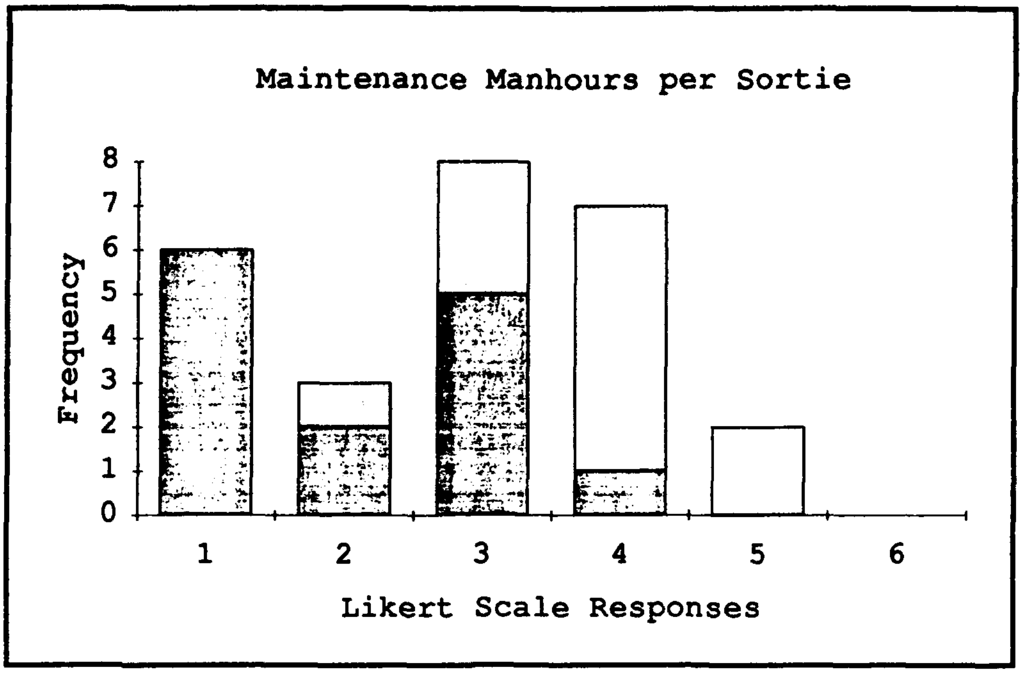
3
4
5
6
Likert Scale Responses


Maintenance Manhours per Sortie
Frequency
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4
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2
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0
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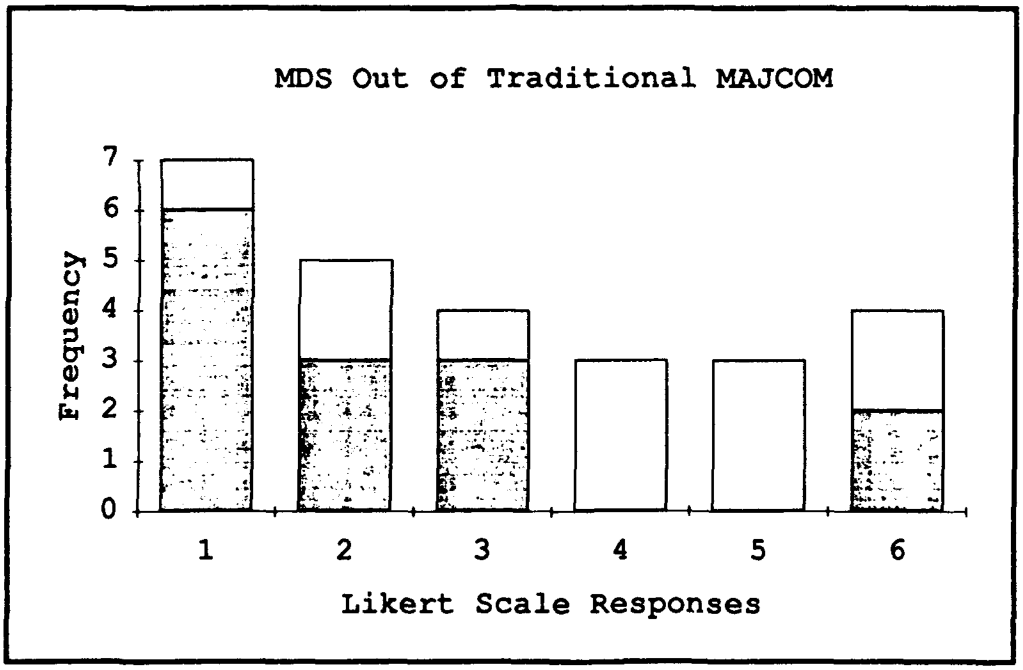
2
3
4
5
6
Likert Scale Responses


MDS Out of Traditional MAJCOM
Frequency
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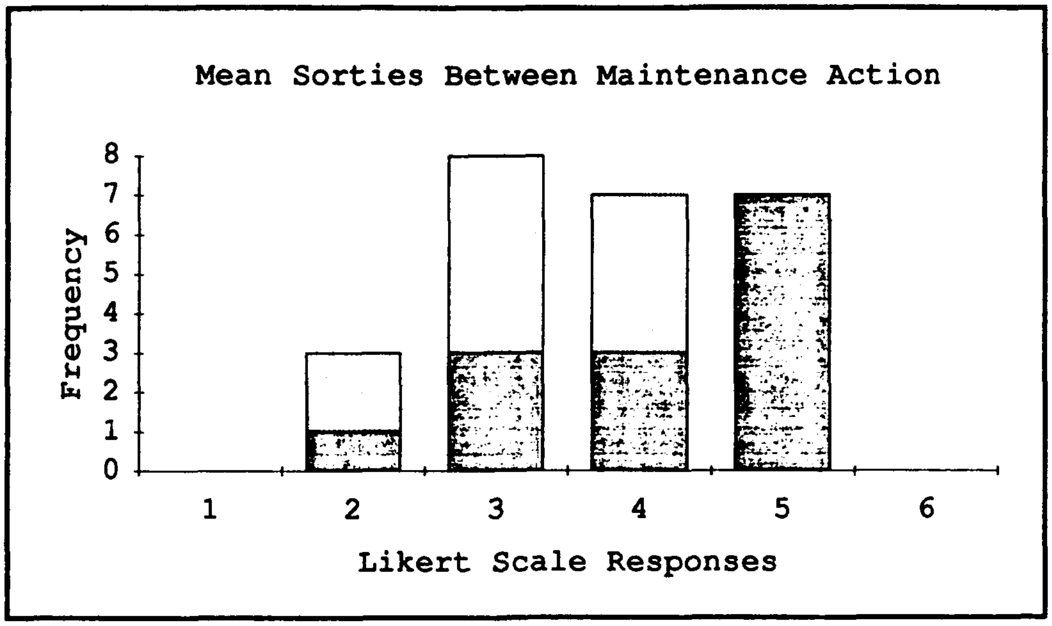
2
3
4
5
6
Likert Scale Responses



Mean Sorties Between Maintenance Action
Frequency
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3
4
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7
8
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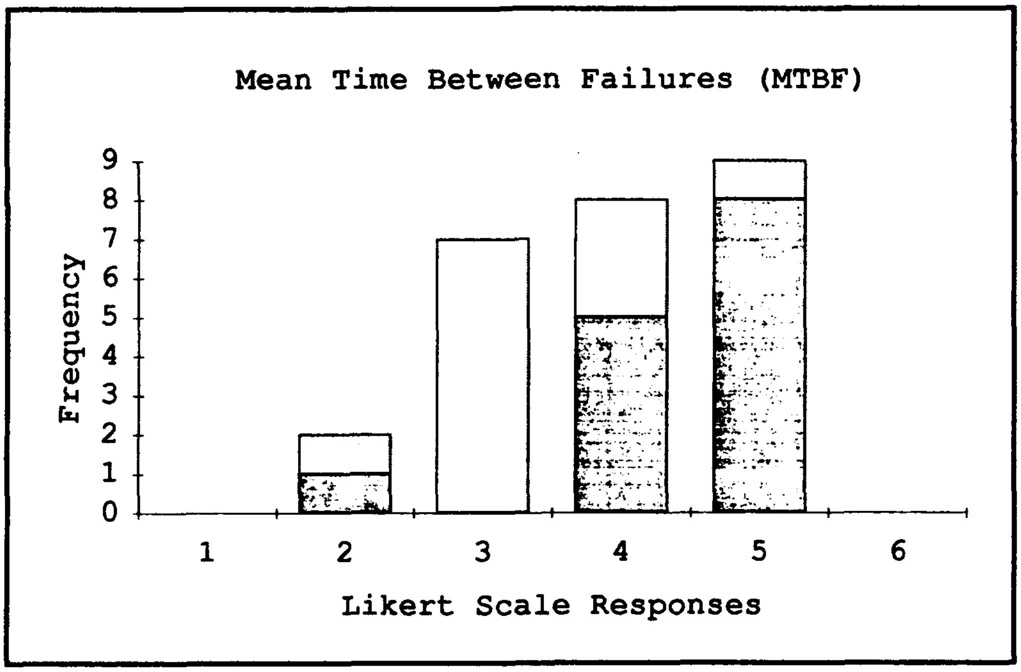
2
3
4
5
6
Likert Scale Responses



Mean Time Between Failures (MTBF)
Frequency
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2
3
4
5
6
7
8
9
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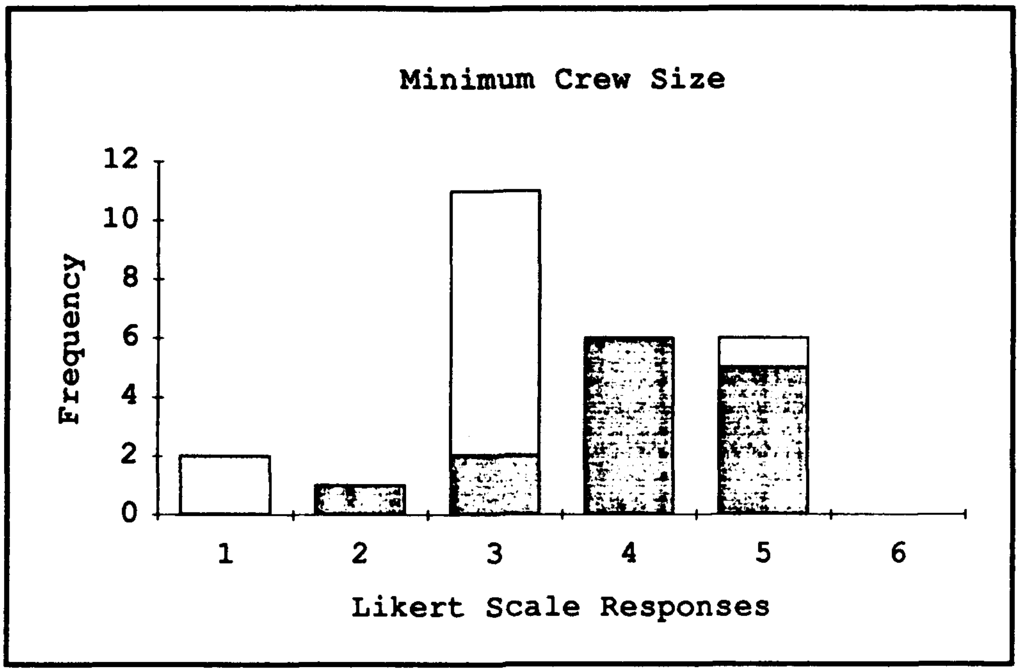
2
3
4
5
6
Likert Scale Responses


Minimum Crew Size
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4
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Frequency
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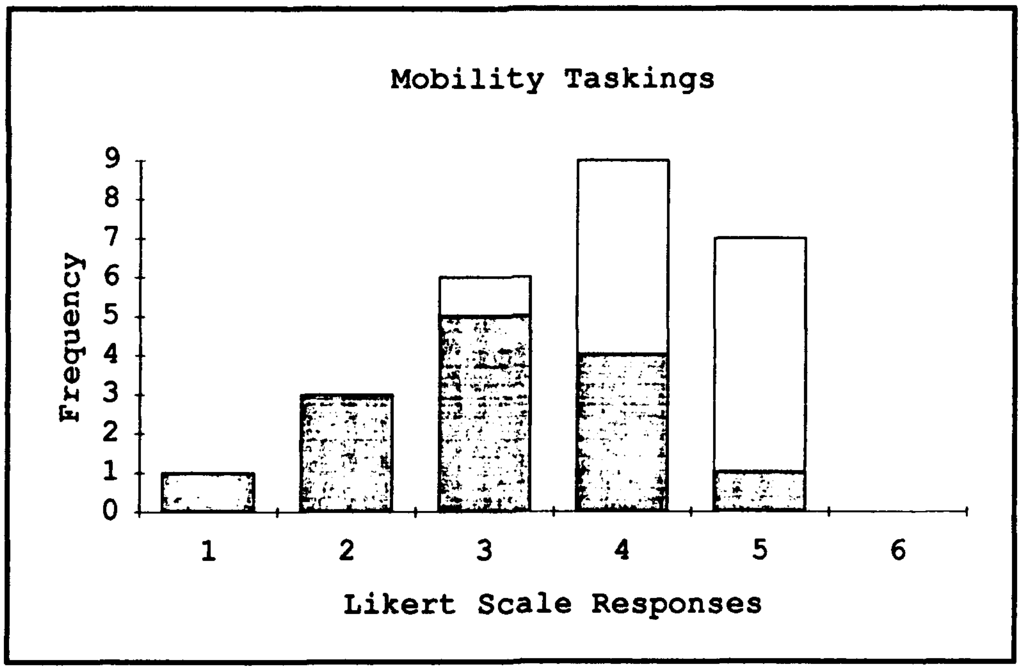
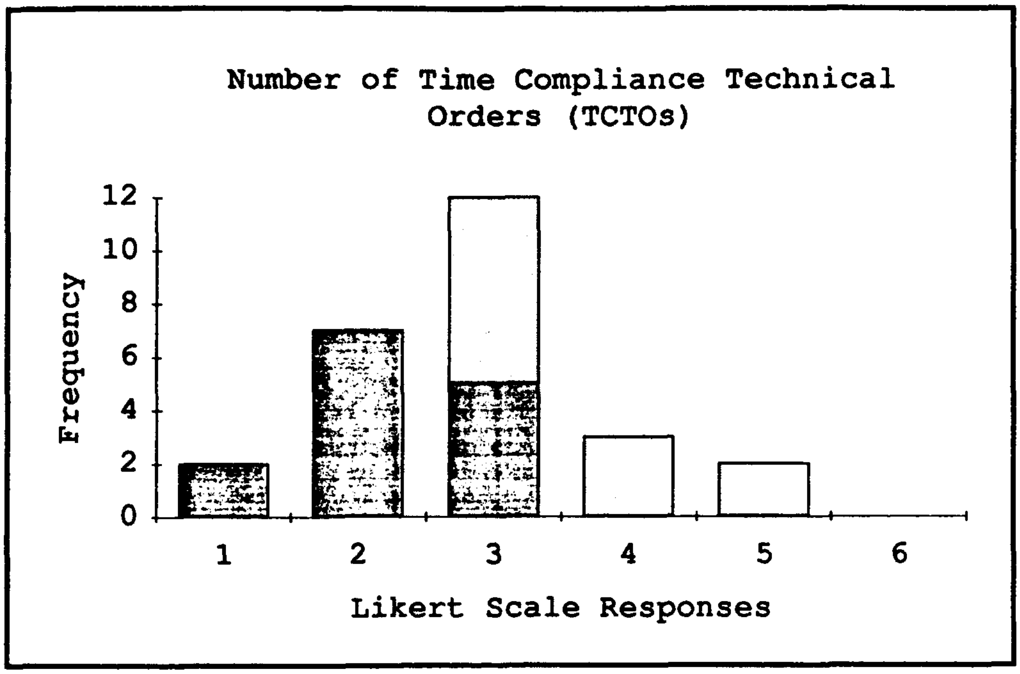
2
3
4
5
6
Likert Scale Responses


Mobility Taskings
9
8
7
6
5
4
3
2
1
0
Frequency
1
2
3
4
5
6
Likert Scale Responses


Number of Time Compliance Technical Orders (TCTOs)
Frequency
12
10
8
6
4
2
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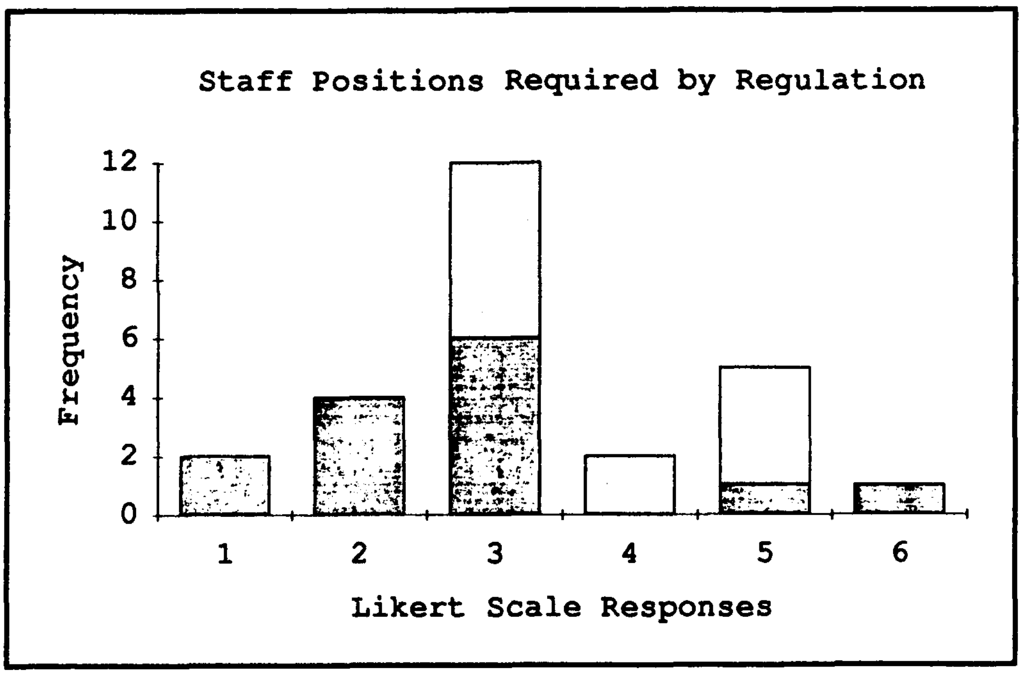
1
2
3
4
5
6
Likert Scale Responses


Staff Positions Required by Regulation
Frequency
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6
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2
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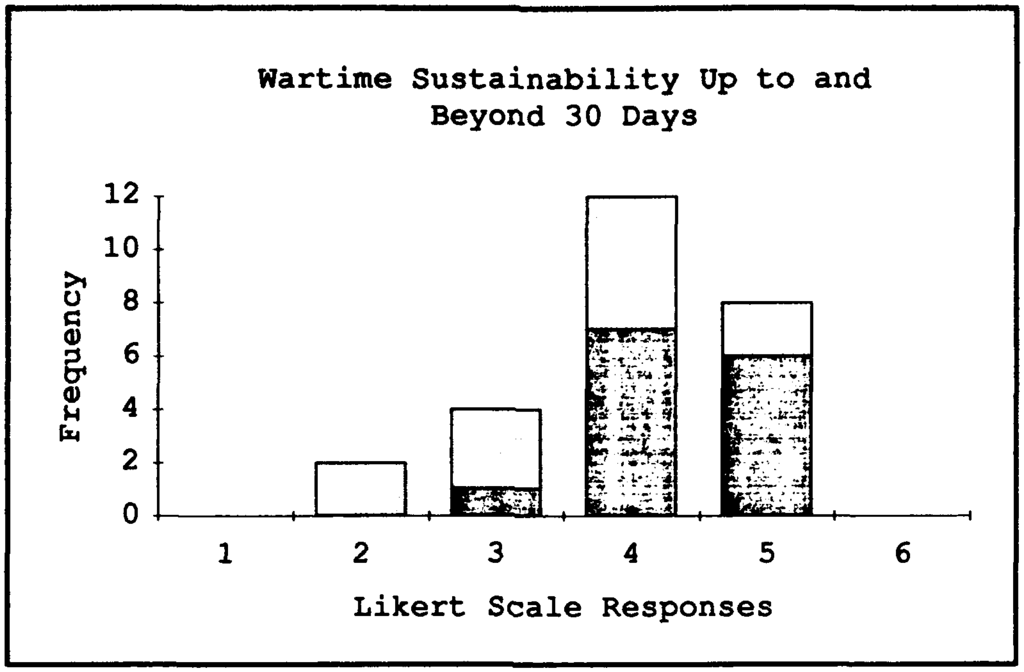
1
2
3
4
5
6
Likert Scale Responses


Wartime Sustainability Up to and Beyond 30 Days
Frequency
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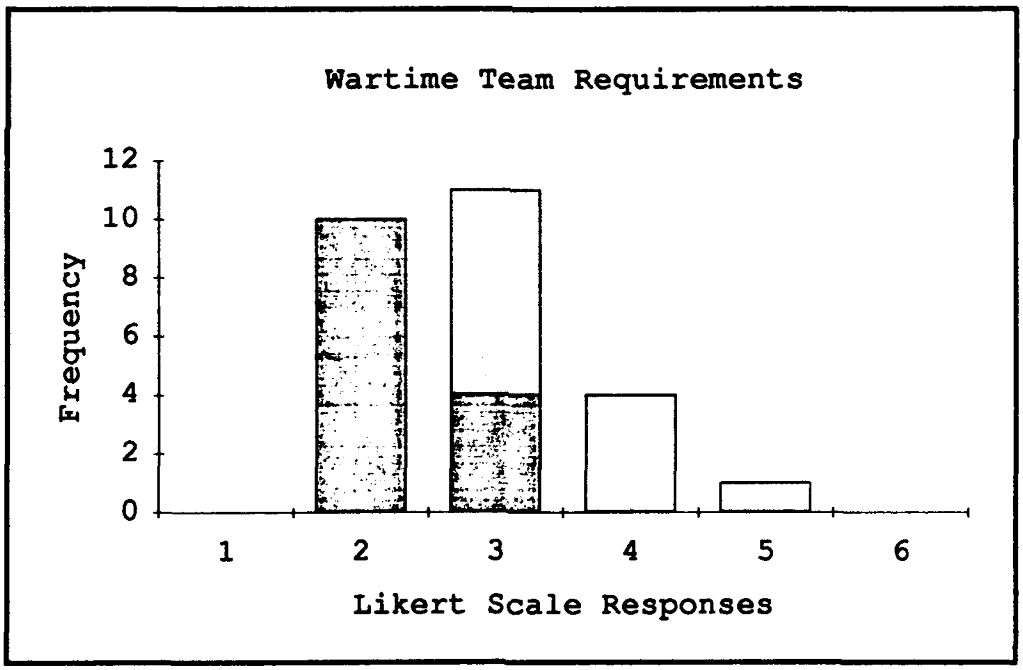
0
1
2
3
4
5
6
Likert Scale Responses


Wartime Team Requirements
Frequency
12
10
8
6
4
2
0
1
2
3
4
5
6
Likert Scale Responses

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In response to changes in threats, the Air Force has reorganized several flying units into composite wings. They are intended to provide a flexible, rapid deployment force. This study focused on the impact of the composite wing organizational structure on the determination of maintenance manpower authorizations at Mountain Home AFB, the Air Force's first air intervention wing. An opinion survey of maintenance and manpower experts was used to identify factors that are important in the determination of maintenance manpower authorization levels. Statistical analysis identified important factors and indicated differences in opinion between maintenance and manpower specialists. Factors specific to the composite wing were also identified. The researchers conclude that at a minimum, three factors must be accounted for in the maintenance manpower authorization process for the composite wing at Mountain Home AFB: primary aircraft assigned (PAA), utilization rate, and deployment concepts.

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